Fig. 1. — Model of the Human Brain [Auzoux]

ELEMENTS OF HUMAN PSYCHOLOG

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PREFACE

THIS book was written to meet numerous requests for an introductory text-book of psychology based on the functions of the nervous system. The standpoint is the same as that of *Human Psychology*, which recognizes both the introspective and behavioristic methods. Material has been freely drawn from the earlier work, but the arrangement of topics is different and the treatment has been simplified. Most of the theoretical discussions are omitted and the practical applications of psychology are emphasized.

Where the book is used as a class text, the instructor is referred to the SUGGESTIONS on page 391.

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ELEMENTS OF HUMAN PSYCHOLOGY

CHAPTER I

SURVEY OF THE FIELD

Meaning of the Term ' Psychology.' — The word *psychology* is often used in conversation and in newspapers or popular magazines without a very clear idea of its meaning. In most cases the speaker or writer is referring to *human nature;* he thinks the mysterious term *psychology* sounds more dignified and imposing, just as stilted writers speak of the ' celestial luminary ' when they really mean the sun. Psychology does not mean human nature; but it does mean something very nearly equivalent to the *study* of human nature. Human psychology is the systematic study of man's daily experiences. It is not merely a description of our doings, feelings, and thoughts, but an attempt to discover *why* we act and feel and think as we do.

Thinking and doing things is not studying psychology, any more than tossing a ball is studying physics, or mixing a Seidlitz powder is studying chemistry. In either case the action may be the starting-point for systematic study; but the study itself involves a great number of accurate observations, and these observations must be put together in an orderly way before we can discover their causes and relations. In other words, when we make a serious business of studying any class of events in nature we (1) collect a large body of facts, (2) classify them, and (3) try to explain how they come to pass. This is what is meant by *scientific investigation.* The results obtained in this way make up the science — physics, chemistry, or psychology, as the case may be.

Psychology is concerned with the scientific investigation of feelings, thoughts, actions, and other events of life. Many of these occurrences are by no means confined to man. Dogs see, hear, and act. The ant is found to possess a keen sense of smell. Even the amœba, one of the very lowest known species of animal, reacts in quite definite ways to certain objects outside of itself which affect it. The field of psychology embraces all these occurrences. It includes the study not only of human beings, but of *all* species of *animals*.

Psychology is not concerned with life in general, but only with certain definite sorts of events in life. It is not the study of bodily growth, nor of digestion or the other processes which maintain the body. The events which we study in psychology are of a different sort from these. They have to do with the *interaction between the living creature and the world in which he lives.*

Every living creature is continually being acted upon by the surrounding world (his 'environment'), and in consequence he reacts upon his surroundings. First the environment affects the creature; then the creature produces some change in the environment. Some of these changes are very obvious; when you open a door, or when your dog paws a hole in the ground, the position of things in the outer world is altered. In other cases the change in the environment is not so evident. But even when you merely turn your head you see things differently; your visual environment is different. There is always *some* change in a creature's environment when he reacts.

Our feelings, thoughts, and volitions arise in connection with this interplay between our bodily organization and our environment. These personal experiences, and all the other events that occur while the reaction is proceeding, are what we have to study in psychology.[1]

[1] Some chemical and physical reactions between the body and its surroundings, such as absorbing food-stuff, the action of oxygen on the lungs,

This special kind of interplay between the creature and his surroundings is called *mental life.* It takes place in a very definite way. (1) Men and animals have a number of special receiving organs, called *receptors*, such as the eye and ear, which gather in the impressions from outside. (2) There are motor organs, called *muscles*, distributed throughout the body, which enable the creature to move in various ways. (3) The receptor organs are connected with the motor organs by means of a vast network of permanent pathways called *nerves*, along which certain *impulses* travel.

The nerves do not connect the receptors directly with the muscles; they extend from the receptors up to the brain and from the brain down to the motor organs. The brain is the connecting link.[1] It consists of a mass of nerve cells and fibers which join the various incoming nerves together and connect them with the various outgoing nerves, somewhat after the manner of the central switchboard in a telephone exchange. The incoming and outgoing nerves and the brain, taken together, make up the *nervous system*, which is the special organ of mental life.

The mental interplay between man and his environment is always by means of receptor organs, nerves, and motor organs; and of these the nerves (particularly the brain) are the most important part. In studying psychology we have to investigate not merely feelings, thoughts, actions, and the like, but the nervous system with its receptor and motor connections; we must study what takes place in these organs when one feels and thinks and acts.

The operation of the nervous system in human life may be illustrated as follows: Suppose a baseball fielder sees a ball coming toward him through the air and raises his hands to catch it. [Fig. 2.] First, his eyes receive the visual impres-

etc., are part of the processes of bodily growth and maintenance and do not belong to psychological study.

[1] There are also short-cut connections below the brain. See ch. ii.

sion of the ball. Then the nerves from the eyes convey an impulse to his brain. From the brain a motor impulse is conveyed through other nerves to the muscles of his arm and hand. Finally, as a result of these motor impulses, the muscles are contracted in such a way that his hand is raised to intercept the ball.

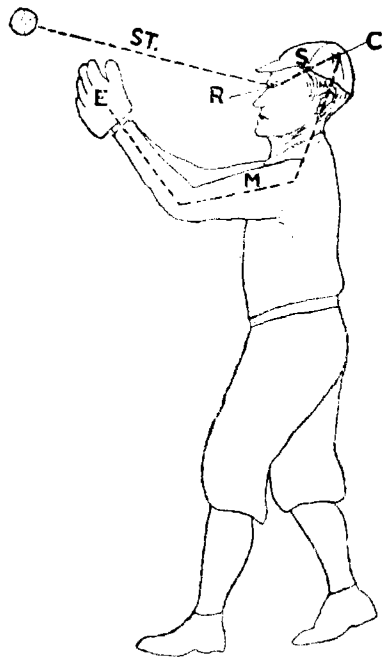

FIG. 2. — SEEING AND ACTING

St. = stimulus; light waves from the ball. R = receptors; the eyes. S = sensory nerves, running from eyes to brain. C = center of nervous system; the brain. M = motor nerves, running from brain to arm. E = effectors or motor organs; muscles of arm and hand.

The actions of animals are due to a similar system of receptor organs, nerves, and muscles. A dog follows a trail because the scent affects his nostrils. A bird flies away because the sound of the hunter's footsteps affects its ears. In every case the impression is conveyed from some receptor organ by means of nerves which finally end in some motor organ, producing the action.

Definitions.— Various definitions of psychology are given in different text-books. Psychology is often defined as the *science of conscious phenomena*, which means the study of feeling, thinking, and the like. Some of the newer books define psychology as the *science of behavior*, which means the study of how human beings and other creatures act. Both of these definitions are correct so far as they go. But each tells only a part of the story — and very different parts at that. It is perhaps better to call psychology the *science of mental life;* but this definition is not altogether

satisfactory, because it does not explain what is meant by mental life. In this book we shall adopt the following definition, which is reached by putting together the results of our previous discussion:

Psychology is the science which deals with the facts and events arising out of the interaction between a creature and its environment by means of receptors, nervous system, and effectors.[1]

This book is concerned especially with the mental life of *man;* and in human beings certain phases of mental life are far more developed than in other creatures. *Thinking* and *willing* are distinctly human affairs; and we can study many other mental events more closely in ourselves than we can in lower animals. This is particularly true of *feeling, perceiving,* and even *emotion.* In human psychology it is important to emphasize these mental facts, — *experiences,* they are called:

Human psychology is the science which deals with the interaction between man and his environment by means of the nervous system and its terminal organs,[2] *together with the mental events which accompany this interplay.*

Problems of Psychology. — These definitions indicate at the outset the fields of study that are *not* included in psychology. It is evident that mathematics and astronomy, physics and chemistry, are not directly concerned with 'interactions between creatures and their surroundings by means of the nervous system.'

In the second place, psychology is not especially interested in the general problems of animal and plant life which biology studies. It is not difficult to distinguish between *biological* life and *mental* life. Biological life depends upon assimilating food and throwing off the waste products. The organs which perform these processes are the mouth, stomach, and intestines, rather than the nervous system. Biology studies such

[1] *Effectors* are muscles and other organs (such as glands) by which the creature produces an *effect.*

[2] The terminal organs of the nervous system include both the receptors and effectors.

processes as nutrition and growth and reproduction. These processes are for the most part chemical and other changes within the body itself. They are quite different from the events of *mental* life which psychology studies.

Biology is interested in finding out, (1) How plants and animals keep alive; (2) How they grow from the egg to maturity; (3) How they repair injuries; (4) How they produce offspring like themselves.

Psychology is interested in studying, (1) What sorts of impressions living creatures get from the world around them; (2) How they get this information; (3) How they use it so as to move and act on their surroundings; (4) How social creatures like man communicate and work with one another.

Interactions between the creature and his surroundings take place continually. In human life they are much more important concerns than feeding and growing. Interplay with the environment is involved in all our pursuits — our studies, business, sports, and home life. Man has devised countless ways of protecting himself against the dangers and rigors of his environment. He makes clothing and dresses himself. He builds houses. He plants crops, raises herds, and catches fish. He has worked out an elaborate system of distributing these food products and other useful material. *All this has been accomplished by means of the nervous system.* Psychology is concerned with discovering how all such actions are performed.

Human psychology, then, deals with the following questions:

What sorts of *information* do we get from the outside world and from our own body?

How is this information *put together* into perceptions, thoughts, desires, emotions, and other mental experiences?

How do we *remember* things and how do we *learn* to do things in the right way?

How do human beings develop a *social life*, by means of which they talk and work together?

How do men come to get such *control* of their environment that they master it and use it for their own ends?

What is man's *personality*, which receives this information about the world and puts it together and uses it?

These are the main problems of human psychology; but each of them includes many lesser ones. For instance, learning to play golf is a very different thing from learning to control your temper; and still different is learning how to manage a business or how to bring up a family. But we shall find that there are certain general rules or laws which apply to *all* kinds of learning.

Collecting the Facts. — The first step in any science is to gather a great mass of facts. In all the sciences that study nature this is done by observing carefully the ways in which nature works. There is always a temptation to guess at things — to imagine that things work in a certain way, because this seems the most likely way for them to act. For instance, men used to think that a heavy body falls faster than a light one. For a long time no one tried it out. Finally, Galileo thought it safer to *observe* than to *guess*. He dropped two balls, a heavy and a light one, from the Leaning Tower of Pisa; — and both reached the ground at the same time. The notion which every one had taken for granted proved to be wrong.

In psychology we are especially apt to use the guesswork plan, because the facts are so much a part of our every-day life that we think we can see them without looking. Everybody who has not studied psychology thinks he has just five senses — with perhaps a 'mysterious sixth' called intuition. But when psychologists began to observe carefully, they found that man has several other senses which had been overlooked. We know now that there are at least eleven senses, and possibly more. The first rule in psychology (as in every study of nature) is to *observe* carefully.

Each science has its own special methods of observing its

facts. Psychology uses three different kinds of observation: (1) observing ourselves, (2) observing the behavior of others, and (3) observing the nervous system and its terminals.

(1) SELF-OBSERVATION, which is also called *introspection*, means the study of our own individual experiences. At the present moment you see this book and other things around you. You are thinking perhaps about psychology or perhaps about your dinner. You may be remembering something that happened to you yesterday. Maybe you have a toothache, or are angry, or are drumming on the table with your fingers. These and other experiences are *events in your own mental life;* by paying close attention to them you gather material for the study of psychology. Self-observation means examining your own experiences carefully. By strict attention you often observe experiences that would otherwise escape notice; — the touch of your clothes against the skin, the tingle in one finger, the throbbing of the heart, a faint noise in the distance.

Self-observation is the most important method in human psychology. It can also be used indirectly. Your friends tell you *their* experiences; this enables you to get at certain mental facts which do not come into your own life, so that you can check up on your own observations. In animal psychology this method cannot be used either directly or indirectly, because even the highest animals do not 'observe their experiences carefully,' nor can they report them to the psychologist.

(2) OBSERVATION OF BEHAVIOR is the study of the way in which human beings and animals act. Notice a group of men listening to a lecture. One man turns his right ear slightly toward the speaker. Another wrinkles his forehead and screws up his mouth. A third scratches his head and twirls his mustache. These are different *attention-attitudes*. When you observe them carefully you are using the *behavior* method of studying psychology. Notice what the fielders

do in a baseball game when the batter makes a hit. Their actions are different, but each act is a form of behavior. All behavior is the result of some impression through the receptor organs. The lecturer's words or the flying ball start the activity; they are called *stimuli*. The attitudes and actions which follow are called *responses*.

It is difficult to observe one's own behavior. If you are fielding a ball you scarcely have time to observe the way you are doing it; your attention-attitudes during a lecture usually escape your own observation. On the other hand it is easy, after a certain amount of training, to study with precision the behavior of others. Behavior study is even more important in animal than in human psychology.

(3) OBSERVATION OF THE NERVOUS SYSTEM AND ITS TERMINALS is used to supplement the two other methods. It means examining the brain to find out how the various nerves run into it and out from it and how they are connected together. Where certain parts of the brain are destroyed by disease, we find disturbances of the mental life. If one region of the brain is affected the man loses the sense of touch; destruction of another region means loss of speech. Paralysis of one side of the body is due to injury of certain regions in the opposite side of the brain.

This method is carried further in animal study by cutting out definite regions of the brain and noticing the effect on the animal's behavior. The results of this animal work are applied to human psychology in so far as the brains correspond. But the human brain is exceedingly complicated; animal experiments do not help us in studying the higher mental processes, which occur only in man.

Another way of observing the nervous system is by making experiments on single nerves and nerve fibers, in order to discover the nature of the nerve current and the laws of nerve activity. This is done by stimulating some nerve with an electric current and noting what sensation or movement

occurs. If electrodes be placed on your forehead and the back of your neck, and a weak alternating current be passed through the circuit, you will see flashes of violet light. Other electric stimulation causes twitching of the fingers.

Examination of the receptor organs also gives some facts *which bear on psychology. The eye and the ear are very intricate organs. A study of their structure helps us to* understand some of the peculiarities of sight and hearing.

Observation of the nervous system has not given as much useful information as one would expect, because in such experiments we observe only part of the effects that occur in real life. Little is known as yet about the real nature of the nerve current in the living body. For these reasons the method of nerve-observation is useful only for checking up some of the results obtained by the two other methods.

Observation and Experiment. — We have used the word *observation* in speaking of these three methods. But in each case the psychologist is often able to make use of *experiment.* The distinction between observation and experiment is this: in observation we watch the way in which things happen by themselves, while in experiment we arrange the conditions beforehand.

If we watch some one learning to typewrite, and notice his mistakes and how he improves, we are getting at the facts by *observation.* But if we give him a page to copy and measure the time it takes him to do it and count the number of errors, our observation becomes an *experiment.* We tell him to practice an hour a day, and at the end of each day we time him for a single page; then we have an experimental measure of his daily improvement. One of the experiments on color sensations consists in giving a person a great many bits of wool of different hues and shades and asking him to match them. The results will show how many colors he can discriminate and whether or not he is color blind.

Experiment is more satisfactory than observation, because

it enables us to get at important facts much more quickly. It may take a long time to discover that a certain person is color blind if we merely observe his actions, while an experiment in sorting out colored wools will usually settle the question at once. On the other hand it is not always practicable *to use experimentation. When we try to study our own experiences, we generally find that we cannot arrange the conditions beforehand without spoiling the effect.* For instance, it is almost impossible to make yourself angry deliberately. In studying anger in yourself, you must wait till something unexpected happens which arouses your anger, and then observe it — if you are enough of a psychologist to do so.

The study of the human nervous system is almost entirely a matter of observation, because we know of no way to take nerves out from the human body or to investigate the brain of a living man without injuring him seriously. In the study of our own experiences, observation and experiment are used about equally.

In applying the behavior method, experiment can almost always be used, and its results are much more satisfactory than mere observation. The wool-sorting test for color blindness is an experiment which uses the behavior method; the person tested arranges the wools in groups or series instead of describing what he sees.

Most of the work in the human psychological laboratory is experimental — a kind of experiment in which human behavior plays a very important part. It would be difficult for any one to determine by mere observation just how long it takes him to think or to recognize a word; but this is measured quite accurately in the laboratory by *experiments on human behavior*. An electric circuit is arranged which starts a clock (called the *chronoscope*) the instant a shutter falls, and stops the clock the instant the observer presses a key. Behind the shutter a word is placed, and then the shutter is released by the experimenter. The person experimented upon sees the

word, and as soon as he recognizes it he presses the key. The clock is running from the instant the word comes in sight to the instant the key is pressed; it records time in thousandths of a second. This enables the experimenter to measure the time required to recognize the word.[1]

After we have arranged the conditions of an experiment, we must watch the events carefully and *must not interfere* with the way they work themselves out. We are not free to arrange results to suit ourselves. An experiment means putting a definite question to nature. It is for nature to answer the question, and we are bound to accept the answer given, even though it is not what we had expected. There is often a great temptation to amend the results so as to bring them out as we think they ought to be. But this is not dealing fairly with nature. If we doubt the correctness of the results, the only proper course is to *repeat the experiment*, taking care to avoid any errors that may have occurred the first time in arranging the conditions or making the measurements.

We find, then, that psychology uses three methods to collect the facts: (1) Self-study, (2) Behavior study, and (3) Nerve study; and in connection with each of these methods it may proceed either (*a*) by observation of events as they occur in nature, or (*b*) by experiment — that is, by arranging the conditions so as to bring out certain facts.

Divisions of Psychology. — We have already noticed the distinction between human and animal psychology. There are a number of other branches of the science which cover special fields of study. In the first place, the name *Human Psychology*, or *General Psychology*, is usually applied to the study of the normal, adult human being. This is distinguished from the study of the human child.

[1] We know how fast light travels, and about how fast the nerve impulse travels from the eye to the brain and from the brain to the finger. This transmission time must be taken into account. The chronoscope is shown in Fig. 79, p. 309.

The object of *Child Psychology* is to discover how each different sort of experience originates in childhood and develops to the precise form found in adult beings. For instance, we may study the beginnings of speech in the child and trace its gradual improvement; or we may study the child's expression of anger and other emotions, and observe how they become suppressed and altered in later life. Simple habits, such as buttoning clothes, tying bow-knots, lacing shoes, are learned by degrees; the first attempts are awkward failures; child psychology seeks to trace the growth of these habits from their very start.

Animal Psychology, also called *Comparative Psychology*, is interested in this same problem of mental growth on a larger scale. In animal psychology we study the evolution of mental life from the lowest species to the highest. It is found that the amœba is not capable of learning by practice. The crayfish can learn a little. If we place a crayfish in a simple maze [1] with food at the other end, after repeated practice he will learn the proper path to the food; he gradually makes fewer mistakes and reaches the food in a shorter time. Animals higher up in the scale of evolution learn more quickly. It is found that the white rat is very intelligent and can learn the solution of rather complicated mazes. Animal psychology also studies the growth of sight, hearing, and other senses, following the course of biological evolution from lower to higher species.

Another branch of the subject is *Abnormal Psychology*. This investigates, among other things, the changes in mental life due to diseases of the brain or other disorders. There are many types of insanity, which come from various causes. Some show themselves in mental depression or wild excitement; other cases are marked by strange delusions; others by inability to speak (aphasia).

It is important to distinguish between *disordered* minds and

[1] See Fig. 73, p. 252.

undeveloped minds. The class of individuals called idiots, imbeciles, and weak-minded are not insane; their minds are merely undeveloped. They are like children in their ways of thinking and acting, though their bodily growth in other respects may be normal. The study of mental retardation, or backwardness, is a division of abnormal psychology quite distinct from insanity.[1]

Physiological Psychology makes a special examination of the nervous system. It studies the different parts of the brain, traces the course of nerves to and from the brain, determines the special activity of nerves and receptor organs, and investigates the relation of nervous activity to mental life. Its findings are used by psychology to throw light on mental processes and behavior.

Experimental Psychology is the name given to the experimental study of human mental life in the laboratory. It is especially concerned with *measuring* the events instead of merely describing them. For instance, experimental psychology tries to discover just *how many* colors can be distinguished; *how long* it takes to memorize a poem, and *how much* we forget in a day or a week; *how quickly* one idea suggests another idea, and what sorts of associations are *most frequent* between two ideas; the *rate* at which we improve in learning new habits, as shown by our speed in performing the act or by the decrease in the number of our mistakes.

Physiological and experimental psychology are really parts of the general branch called human psychology. We separate them for special study because they involve the use of delicate instruments and require special training on the part of the student. Many of their results are included in textbooks on human psychology.

[1] The study of blindness, deafness, and other peculiarities which depend on defective receptors, might be included under abnormal psychology. But these defects do not make the individual 'pathological,' like insanity and mental retardation; so they are generally studied in connection with normal psychology.

In the same way we may pick out any topic for special study and regard it as a division of psychology. The *psychology of religion* is a special study of religious experiences; *psychophysics* is an experimental study of the relation between stimuli and sensations; the *psychology of play* investigates the origin, development, and varieties of play in man or in different species of animals.

Social Psychology studies the events which occur when one being acts upon another, or when a group of individuals act together. For instance, imitation means that one person copies the actions of another; the second influences the first — it may be quite unconsciously. Teaching means that one individual *tries* to arouse certain thoughts in another. Speaking and writing are social events; they are generally directed toward some one else. Our moral acts depend on our recognition that other human beings have feelings like our own. In a crowd and in a community there is always a tendency for individuals to think along the same lines and to act more or less as a unit; an individual acts differently in a crowd than when he is alone.

All these are examples of the kinds of events which social psychology studies. Social psychology should not be confused with sociology. Sociology studies social and industrial relationships of every sort, while social psychology is concerned only with actions and behavior which are accomplished by means of the nervous system.

Applied Psychology is not a division of psychology like those just discussed; it means the art of using in practical ways the results obtained from psychology. After we have discovered how the human mind works, certain tests may be arranged by which we can size up any individual mind. For instance, if we know what sort of mental processes are needed in a certain occupation, we may devise tests for picking out the most promising persons from among the candidates who are seeking the position. Mental tests are used to discover

whether a given person has the mental qualifications to make a good salesman or a good telephone operator. Other kinds of tests are used to indicate whether a child belongs in the same school-class as those of his own age, or should be placed in a higher or lower class. The degree of mental retardation in morons and imbeciles is determined in a similar way.[1]

Another use of applied psychology is in connection with advertising. One advertisement will attract more notice than another; some advertisements unintentionally repel the average man. It is the task of applied psychology to find out what sorts of advertisements appeal to the average human being — to lay down laws about what to do and what to avoid in advertising. These laws depend on a knowledge of human nature; they are applications of principles which have been discovered by the study of psychology. In general, applied psychology is the application of psychological principles to practical problems of life.

The important divisions of psychology, then, are as follows:

Human or general psychology (study of the normal adult)
Child psychology
Animal or comparative psychology
Abnormal psychology (insanity and mental retardation)
Physiological psychology } specialized studies
Experimental psychology }
Social psychology
Applied psychology (practical applications)

Summary and Outline. — Psychology is the science that studies the interaction between human beings and their environment which occurs by means of the nervous system. Like every other science, psychology gets its facts by observation and experiment. There are three methods of observing psychological facts: observing our own experiences, observing the behavior of others, and observing the workings of the nervous system.

[1] A *moron* is less deficient mentally than an imbecile. The word was coined as the result of mental tests, which showed that in addition to idiocy and imbecility there is a third, superior grade of mental retardation.

Besides the study of human psychology there are several other fields of psychological investigation, such as animal, child, and social psychology. Applied psychology is the application of psychological laws and principles to practical problems in life.

In this book we are to study human psychology. How shall we go about it? By our definition, human psychology is the attempt to discover — systematically — how men are influenced by their surroundings; what sorts of experiences occur in human life; how men react upon the world around them; how human character and personality are formed. When we study these problems we must begin at the foundation. You will not understand the meaning of personality unless you first examine the various kinds of experiences that enter into its make-up. Speech and voluntary action cannot be explained without some knowledge of the nervous system and how it works.

The objection to most attempts at psychology by untrained writers is that they generally begin at the wrong end. Most of the popular articles on metaphysical psychology, new thought, mental concentration, and the like, treat mind as a simple unit instead of a composition or product. They commence with the universe instead of the atom. If we wish to understand mental life and human nature we must start at the bottom and work up.

The first step is to study the nervous system (ch. ii) and how it works (ch. iii), since all our thinking and acting depend on nerve connections. Then we examine the receptors, and the sensations which we get through their operation (chs. iv, v). This furnishes the foundation for the science.

Man's conscious life is made up of experiences, and each particular experience is a union of many separate sensations. After we have made a survey of the senses, we are in a position to examine their relation to conscious life (ch. vi). The next step is to study the different kinds of experiences that

enter into man's daily life (chs. vii–xiii). But mental life includes actions as well as experiences. So in studying certain kinds of human experience we have to examine the various forms of behavior, such as instinct and intelligence (chs. x, xi).

Thus far our study is confined to single, definite experiences and actions. We now go further and examine the succession of experiences which change from moment to moment (ch. xiv). Finally, we may trace the process by which man's personality is built up out of these successive experiences and how he gradually gains control over his actions and becomes master of himself and his surroundings (chs. xv, xvi).

This is a systematic order of studying the subject. One step leads to the next. It avoids the popular error of assuming that such complex things as mind, will, and intelligence are simple and fundamental.

PRACTICAL EXERCISES:

1. Report briefly (1) some *feeling* you have had lately; (2) some *memory* you have recently recalled; (3) some *thought;* (4) some *action* you have just performed. Bring out as far as possible the difference between these four experiences.
2. Take two recent instances in which the environment has affected you and then you have acted on the environment. Describe the whole chain of events as far as you can observe them.
3. Say the word "Man" out loud. Now describe this occurrence (your speaking) in two different ways: (1) As you observe yourself talking; (2) As another person would observe you doing it. Compare the two descriptions.
4. Observe a young child's speech or handwriting; compare it with that of an adult and point out any evidence of mental immaturity which the comparison brings out.
5. Report some instance where you have been carried away by the influence of a crowd. Describe how your actions and feelings have been influenced, and explain the reason so far as possible.

[Exercise 1 is on the different sorts of experience; 2 is on our relation to the environment; 3 is on the distinction between self-observation and behavior-observation; 4 is on child psychology; 5 is on social psychology. See p. 391 for Suggestions in performing the exercises.]

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CHAPTER II

STRUCTURE OF THE NERVOUS SYSTEM

Cells. — The human body is composed of a vast number of units called *cells*. These cells are formed of substances which are chemically very much alike, and every living cell contains a *nucleus*, which is essential to its life. There are many kinds of cells which differ in shape, degree of rigidity, and other characteristics. [Fig. 3.] Each of our bones is made up of a number of bone cells united firmly together. Our blood contains a mass of floating corpuscles, each a separate cell. Our skin is a network of epithelial cells which are not so firmly compressed together as the bone cells, and allow stretching and other changes in shape. The stomach, heart, and other internal organs are made up of cells, each organ being built up of some special sort of cell.

The nervous system and the terminal organs connected with it are formed in the same way. The nerves are composed of cells of a very unusual kind: they are very long and thin, like threads, so that the name *cell* seems a misnomer. The special receptors (such as the eye and ear) are composed of several different kinds of cells. The muscles are formed of muscle cells joined together into long bands or strips: when a nerve impulse affects them each strip contracts and the whole muscle is shortened.

Our body grows by the enlargement and splitting up of its cells. When a cell reaches a certain size, it divides by a complicated process into two cells, each of which is like the 'parent' cell. In course of time a cell may die, just as a living being dies. It is then disposed of as waste matter, and a new cell (formed by the division of some living cell of the same kind) takes its place. When a man reaches maturity the death of old cells just about balances the production of

new, so that he ceases to grow. But man is still able, until late in life, to restore sections of skin and flesh, and to knit together bones that have been injured.

Every living creature starts as a single cell of a special sort, called a *germ cell*, which, when it is fertilized by union with

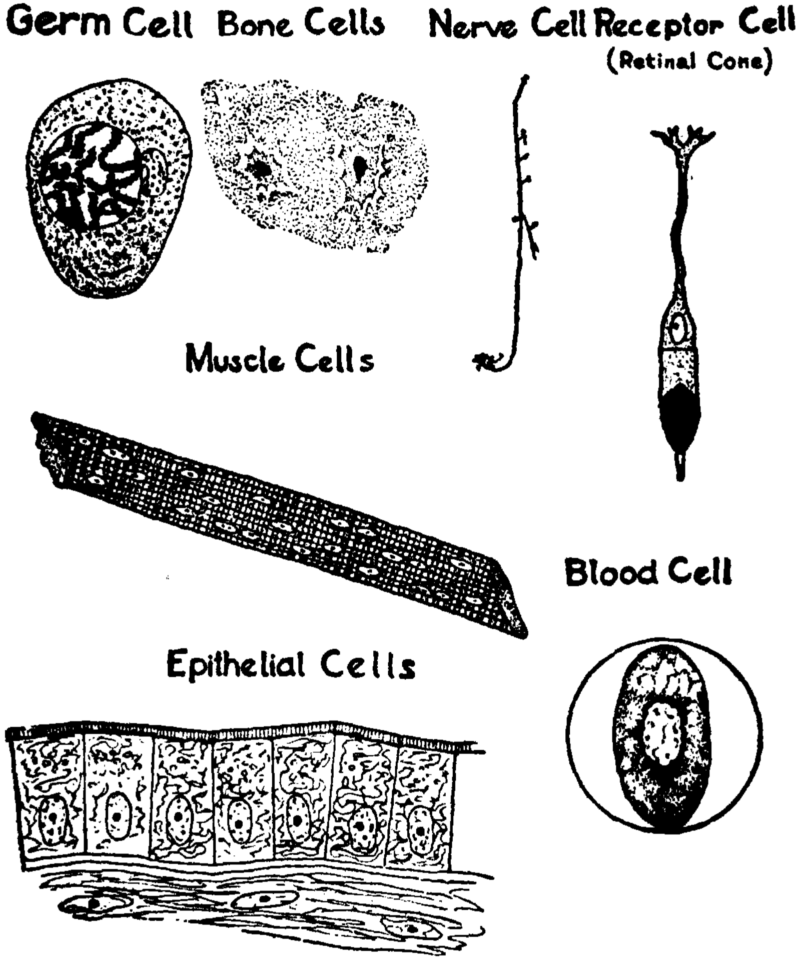

FIG. 3. — DIFFERENT KINDS OF CELLS

Some of the principal cells which make up the body; greatly enlarged in the drawing. The human body contains many other varieties of cells.

another germ cell of the opposite sex, begins to grow and subdivide. The cells first formed in this growth process are not all alike; they are the starting-point for the bones, skin, inner organs, nerves, and other components of the body. As the division of cells continues the body gradually takes shape, and its various parts begin to be formed.

The cells composing the human *nervous system* develop rapidly in the embryo, and practically all of them are formed before birth. Their number is astonishingly great; there are over nine billion nerve cells in the outer layer (cortex) of the brain alone.

The Neuron. — The separate cells which make up the nervous system are called *neurons*. In the neuron the main body of the cell, which contains the nucleus, is very small compared with the rest of the structure. The important feature is a long thread-like fiber which projects out from the cell-body, and usually has several branches.

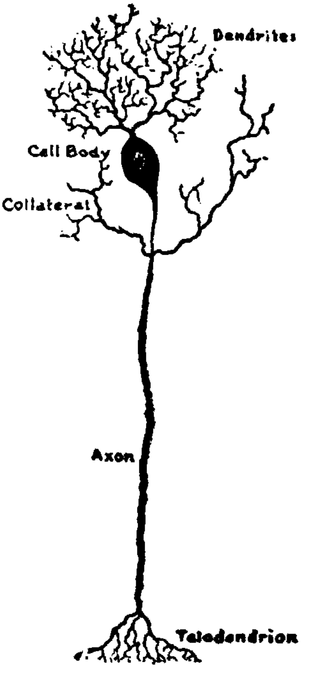

FIG. 4. — THE NEURON AND ITS PARTS

Fig. 4 shows one sort of neuron, in which a long fiber, called the *axon*, extends from the cell-body in one direction, terminating in very fine fibrils, called the *telodendrion*, or *endbrush*. The axon is usually provided with branches, called *collaterals*. At the other end of the cell-body there is a larger network of fibrils, called *dendrites*, which branch out like a tree. There are several other varieties of neuron [Fig. 5], in some of which the fibers extend in both directions from the cell-body.[1]

[1] In both Figs. 4 and 5 the thickness of the fibers is exaggerated, otherwise

The length of the axon varies considerably. Some axons are very short; they belong to neurons which link together two neighboring neurons in the spinal cord within the back-

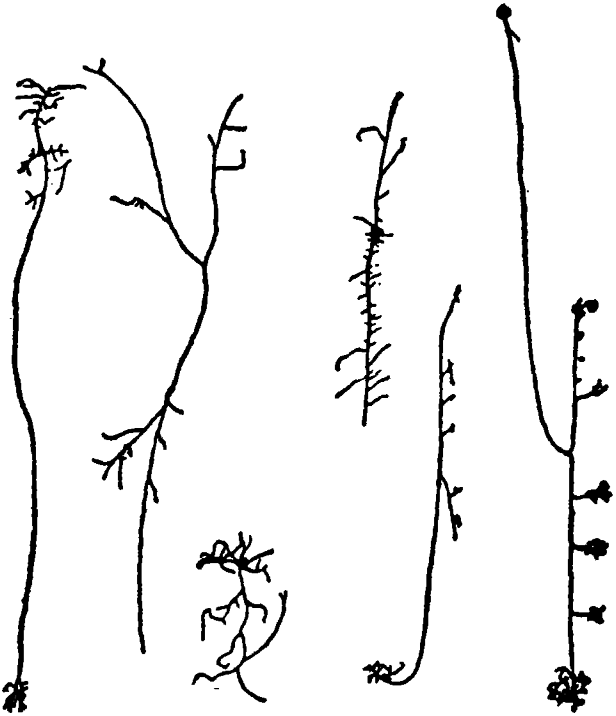

FIG. 5. — VARIOUS TYPES OF NEURONS

Six different sorts of neurons. Notice the small size of the cell-body and great length of the axon. In the drawing the thickness of axon and collaterals is exaggerated, and the finer fibrils do not show. [From Thorndike.]

bone. There are other neurons whose axon fibers are more than two feet in length, extending all the way from the toes to the spinal cord. The point to remember especially about the neuron is that it is a *line of conduction* or pathway along which nerve impulses travel.

they could not be seen in the picture; in Fig. 4 the size of the cell-body is drawn too large compared with the projections, so as to show the nucleus.

The Synapse. — In the general arrangement of the nervous system each neuron connects up end to end with another neuron.[1] A series of neurons joined together in this way form a chain or circuit which extends from the eye or ear or some other receptor to the brain, and from the brain to some muscle or gland; every receptor is the starting-point of a nerve circuit, which terminates in some effector. These circuits are called *nervous arcs.*

The connection of successive neurons in the nervous arc is not a complete soldering of the ends together. It is a peculiar sort of connection, not fully understood. The minute branching fibrils at the far end of one neuron are meshed in with the fibrils at the near end of the next neuron, like the branches of two bushes close together in a clump. At these intermeshing points the nerve impulse passes across from one neuron to the next, just as in a copper wire of many strands the electric current passes over to another piece of wire when the strands of the two are meshed together. The junction point of two successive neurons is called a *synapse.* [Fig. 6.]

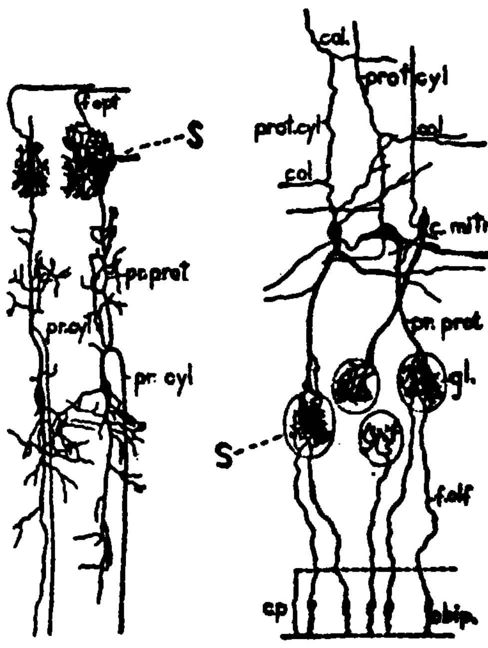

Fig. 6. — Various Types of Synapses
S = synaptic regions, where two neurons mesh together.
[From Thorndike, after Van Gehuchten.]

[1] The side connections by means of the collaterals should not be forgotten. They correspond to the branching of an electric lighting system.

The synapse does not transmit nerve impulses as readily as the nerve fiber; it offers more or less resistance to the passage. Sometimes the resistance at a synapse is so great that the impulse is unable to pass over at all into the next neuron. In such cases the pathway is blocked, and either (1) the impulse goes no further, or (2) it passes into some collateral and through the synapse at its end into a neuron belonging to a different circuit. The synapses and the resistance which they offer to the transmission of nerve impulses are very important factors in determining what pathway a given nerve impulse will take. Our ability to learn new actions depends on the shunting of nerve impulses into new paths by means of collateral synapses.

General Plan of the Nervous System.—The neurons are not scattered through the body promiscuously. They form great masses in the head, constituting the brain; elsewhere in the body a number of neurons run close together in

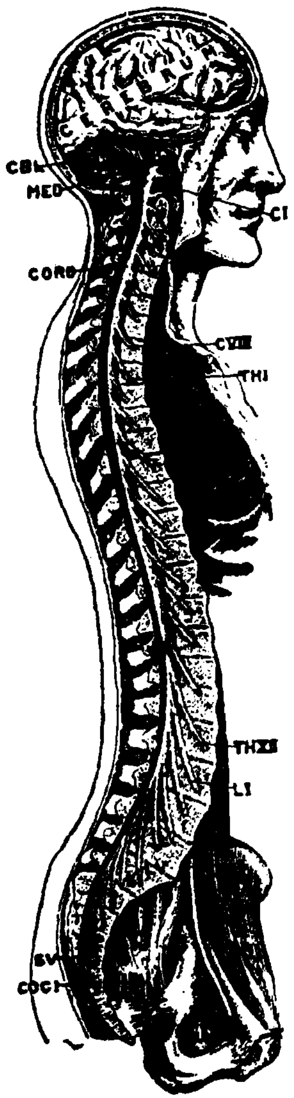

FIG. 7. — BRAIN AND CORD IN POSITION

In the head is the brain, consisting of the cerebrum and beneath it the cerebellum (CBL) and medulla (MED). The spinal cord is the long white line extending down from the medulla. The peripheral nerves branch off from the cord at intervals; their beginnings are shown projecting down toward the right in the drawing. C I to C VIII = cervical nerves; TH I to TH XII = thoracic; L I to L V = lumbar; S I to S V = sacral; COC I = coccygeal.

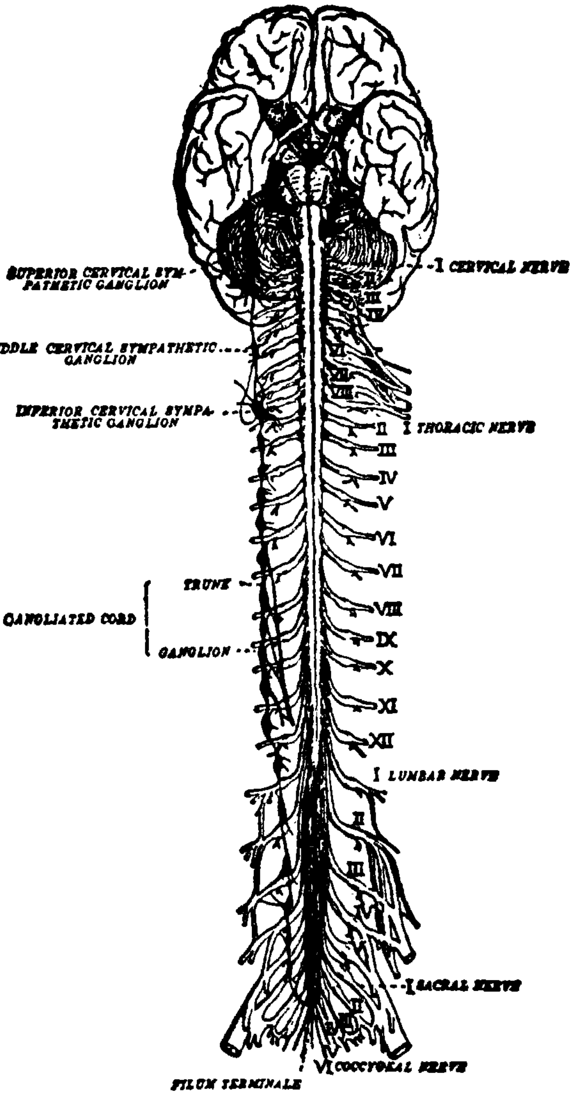

FIG. 8. — CENTRAL PORTION OF NERVOUS SYSTEM

Viewed from the front. The brain extends down to '1 cervical nerve'; below this is the spinal cord with beginnings of the peripheral nerves as they leave the cord (numbered at right). To left (very black) are shown the sympathetic ganglia of the autonomic system: the corresponding ganglia to right of cord are not shown. [From Herrick, after Allen Thompson and Rauber.]

bundles. The *nerves* which are visible to the naked eye are bundles of neurons lying side by side. The individual neurons in any such bundle or nerve are insulated from one another. The nerve impulse does not jump across from one neuron to those beside it, but passes along the same fiber to the synapse at the end, and over into another neuron which is the extension of the same path.

The main nervous system[1] consists of the *brain, spinal cord,* and *peripheral nerves.* [Figs. 7, 8.] There is also a somewhat independent system of nerves called the sympathetic or *autonomic system,* which controls our digestion, heart, and other internal organs. [Fig. 8; cf. Fig. 15.]

Peripheral Nerves. — The *peripheral nerves* are the pathways which connect the centers in the brain or spinal cord with the receptors or effectors. They are of two sorts: *sensory* and *motor.* The sensory nerves connect the receptors with the cord or with the brain; they carry nerve impulses inward from some receiving organ to some center. The motor nerves connect the cord or brain with the muscles and other effector organs throughout the body. They carry nerve impulses out from some center to some effector.[2] The sensory and motor nerves which connect with parts of the body *below the head* pass into the cord on their way to or from the brain; they are called *spinal nerves.* There are also sensory and motor nerves in the head which enter the brain directly, without passing through the cord; these are called *cranial nerves.* For instance, the olfactory nerve is a sensory cranial nerve leading from the smell receptors in the nostrils to the center for smell in the brain. There are also motor nerves leading from the brain to the face muscles which are used in smiling; they do not pass through the spinal cord.

Spinal Cord. — The spinal cord runs up the back from the

[1] Called the *cerebrospinal system.*

[2] There are also *mixed* peripheral nerves, which contain both sensory and motor neurons, grouped into separate bundles, but running side by side.

lower extremity of the trunk to the head, where it enters the brain. Roughly speaking it is about as thick as your little finger. It lies inside the backbone. The separate segments (vertebræ) which make up the backbone are hollow, and the cord lies within this hollow tube. The nerves enter or leave the cord in the space between each pair of vertebræ. [Fig. 7.] At each vertebral juncture two sensory nerves enter the cord — one from the right, one from the left — and two motor nerves go out. [Fig. 8.] The sensory and motor nerves on the left side join together just outside the cord [Fig. 9] and run as a single nerve to the region of the body where they terminate; there the nerve breaks up and each neuron proceeds separately to its final destination. The corresponding sensory and motor nerves on the right side proceed in a similar way. Both of the sensory nerves (right and left) enter the cord from the *dorsal* direction — that is, at the *back;* while the motor nerves pass out in the *ventral* direction — that is, toward the *front* of the body.

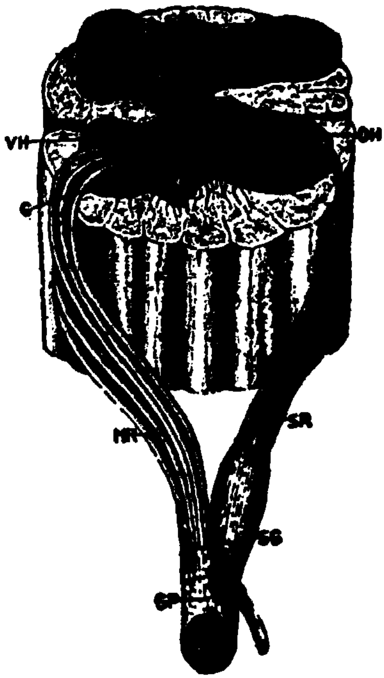

FIG. 9. — CROSS-SECTION OF CORD

The central gray matter (G) is shaped like an H, and is surrounded by white matter (W). From the ventral or front horn (VH) of gray matter emerges the motor root (MR) of a spinal nerve (SP); the sensory root (SR) of the same nerve enters the dorsal or back horn (DH), which is more pointed than the ventral. Near the junction of the two roots is the spinal ganglion (SG) consisting of sensory cell-bodies.

The nerve shown in the figure is on the left side of the body; the roots of the corresponding right-side nerve join the cord at the farther pair of horns. [Modified from Testut.]

If we cut through the cord horizontally, it is seen as a mass

of whitish substance, surrounding a grayish mass which looks somewhat like the letter H. [Fig. 9.] The gray matter is composed largely of cell-bodies with the fibers leading into them. The white matter is composed of axon fibers with no cell-bodies. The difference in coloring is due to the grayish tinge of the cell-bodies.

The peripheral sensory and motor nerves from all over the body below the head pass into the gray matter of the cord and terminate there. At their terminus in the cord they connect with two distinct paths: (1) There are *reflex connecting neurons* in the gray matter which join the ends of the sensory neurons directly with the ends of the motor neurons in the cord, so that a nerve impulse may come into the cord and pass out immediately, without going up to the brain. This direct connection is what causes the knee-jerk and other spinal reflexes. (2) There are also *secondary sensory neurons* connected with the ends of each sensory neuron in the gray matter of the cord which lead up to the brain, and corresponding *secondary motor neurons* which descend from the brain and connect with the peripheral motor neurons in the cord. These indirect connections are used in voluntary movements. The white matter of the cord is made up of these conducting fibers which connect the brain with the peripheral sensory and motor neurons.

The H shape [1] of the gray matter in the cord is due to these connections: (1) The direct reflex connections between the sensory and motor fibers form the two uprights of the H; and (2) the sensory fibers (with gray cell-bodies), crossing over from right to left before they pass up toward the brain, make the cross-bar.

The thickness of the cord varies. It is thickest near the head and tapers down at the lower end. This is because a pair of nerves pass out at each of the vertebral openings, reducing the size of the cord as we proceed downward. The

[1] Turn Fig. 9 left side up and you see the H clearly.

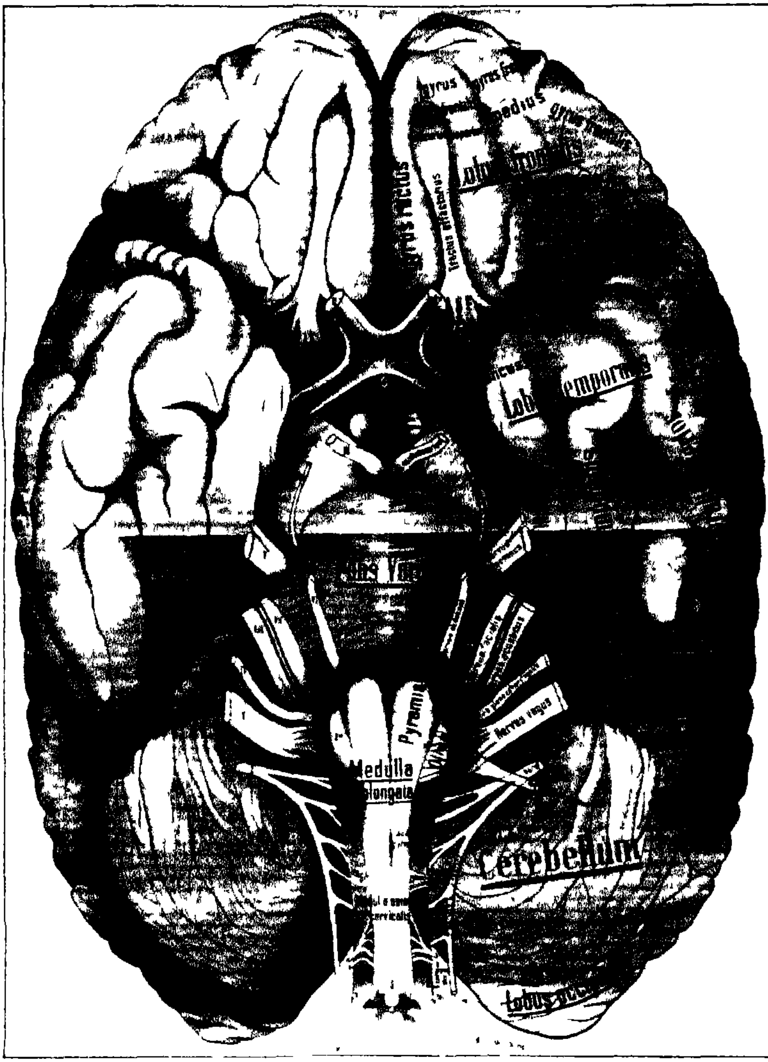

Fig. 10. — Base of Brain

Brain viewed from below looking upwards. Front of head is at top of the drawing, back of head is at bottom. In the drawing the pons, medulla and cerebellum are supposed to be nearer you than the cerebrum. Basal ganglia lie in center of picture. Lobes of cerebrum (lobus) are underscored. Small folds of the lobes, called convolutions (gyrus), are named (right side). Cranial nerves are named (right) and numbered (left). Beginning of spinal cord (medulla spinalis) is shown below. [From Strümpell and Jakob.]

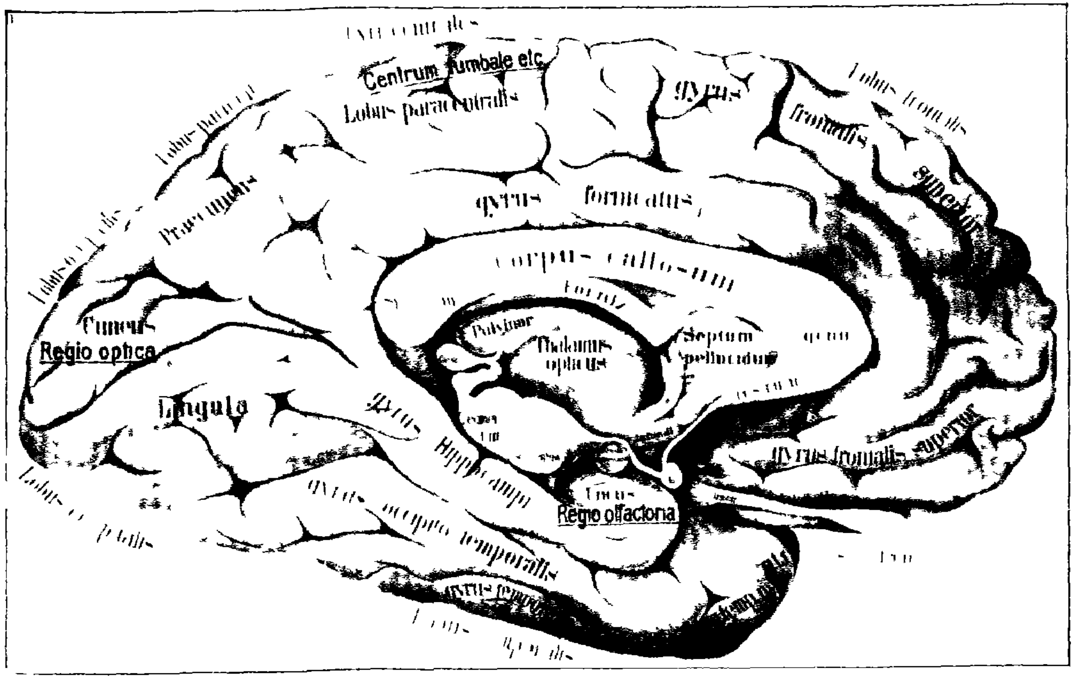

FIG. 11. — MIDDLE CROSS-SECTION OF BRAIN.

Vertical view of left hemisphere along medial fissure. Front of head is at right side of the drawing. Corpus callosum is cut in two; below it are the basal ganglia, with thalamus in the center. Cortical center for sight (regio optica) at left; center for smell (regio olfactoria) at right. [From Strumpell and Jakob.]

decrease is not uniform; there are two distinct bulges: one where the great nerves of the arms leave the cord, the second where the nerves pass out to the legs.

The spinal nerves are named according to the region of the body which they serve, and within each region they are numbered from the top downward. There are in all thirty-one pairs of spinal nerves. [Fig. 8.]

The sensory nerves which enter the cord from the right side connect with neurons that cross over and pass up on the left side, and vice versa; in every case the sensory paths in the cord are on the *opposite* side from that on which they enter. The motor fibers generally cross at the upper end of the cord, so that the motor paths in the cord are on the *same* side as the peripheral motor nerves with which they connect. But in every case the sensory and motor nerves which serve the right side of the body connect with the left side of the brain, and vice versa. In other words, the left side of the brain receives impulses from the right side of the body and controls movements on that side, while the right side of the brain is connected with the left side of the body.

The Brain. — The human brain is a very intricate affair.[1] It consists of the *medulla oblongata*, *cerebellum*, *pons Varolii*, and *cerebrum* or great brain; the cerebrum is divided into the *basal ganglia* and the *cortex* or covering.[2] In addition there are twelve pairs of *cranial nerves*, which connect with receptors and effectors in the head. [Fig. 10.]

Of the twelve *cranial nerves*, some are sensory, some motor, and some contain both sensory and motor branches. Sensory nerves or branches connect with the eye, ear, and organs of taste and smell, and with receptors for the sense of touch in the lining of the mouth and nose, and in the skin of the face.

[1] See Frontispiece. If possible a brain model or specimen should be examined.

[2] The term *brain-stem* is used to designate all the brain except the cerebellum and the cortex with its connecting tracts.

It is through these nerves that we get sensations of sight, hearing, and the other special senses, as well as touch sensations from the skin of the head. Motor nerves lead to the various muscles in the head, including the eye muscles and those of the lips, tongue, jaws, and throat which are used in eating and speaking. The cranial nerves and receptors will be examined in more detail in connection with sensation (chs. iv, v).

The *medulla* is really a continuation of the spinal cord, but is much thicker. It is the region where the motor fibers cross, and it is also the assembling point for fibers connecting the cord with the various parts of the brain beyond.

The *cerebellum* is a spherical mass of nervous matter which lies at the back of the medulla and somewhat above it. It contains centers for coördinating our movements; by means of its activity we are able to maintain our equilibrium and to make other simple motor adjustments without special attention.

The *pons* is a broad band of nerve fibers lying in *front* of the medulla and crossing it horizontally. It is situated somewhat above the cerebellum.

Immediately above the parts just mentioned is the *cerebrum* or great brain. Its interior consists of a number of odd-shaped masses of nervous matter called the *basal ganglia*, which serve various purposes in the reception and treatment of nerve impulses. Some of these masses connect with the cranial nerves; others are intermediate stations between the cord and cortex. It would require an undue amount of time to describe their relative position and uses, and this can only be done satisfactorily in connection with an examination of a brain model or actual dissection. For our purpose the most important basal ganglia are the two *optic thalami*,[1] right and

[1] This name was adopted because the thalami were found to lie at the end of the optic nerves. Later they were found to be the terminals of other sensory nerves also; the olfactory nerve is apparently not connected with

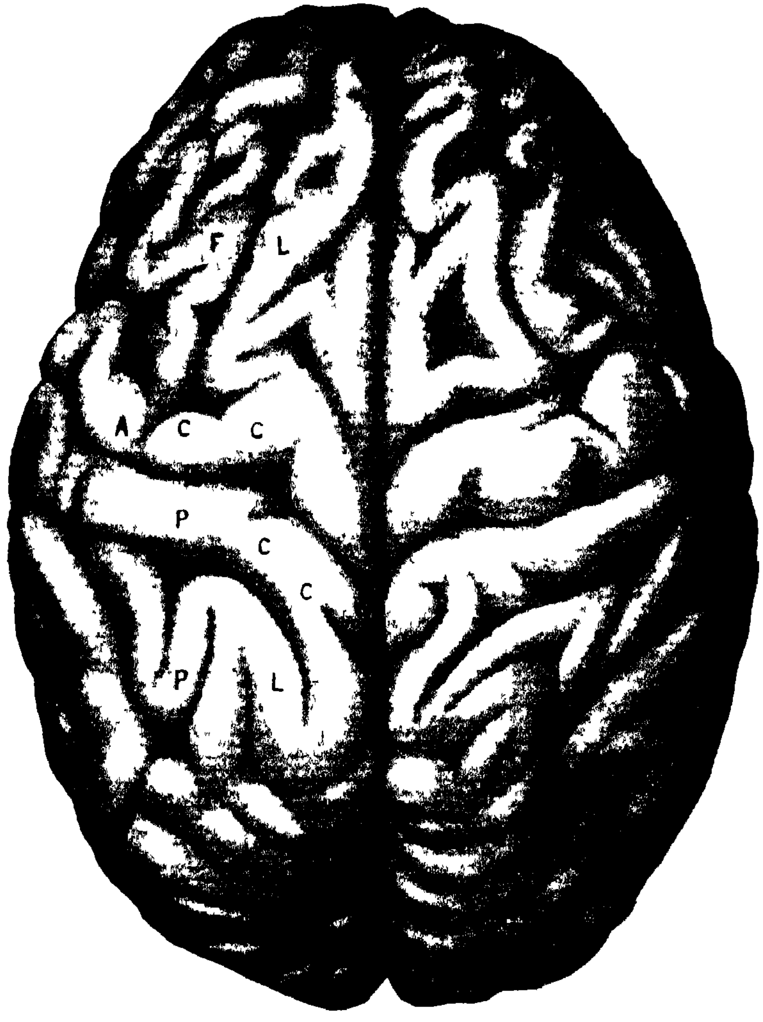

Fig. 12.—Cortex from Above

Showing the hemispheres, separated by the medial fissure. Front of head is at top of the drawing. FL = frontal lobe, ACC = anterior central convolution, RF = Rolandic (or central) fissure, PCC = posterior central convolution, PL = parietal lobe, OL = occipital lobe.

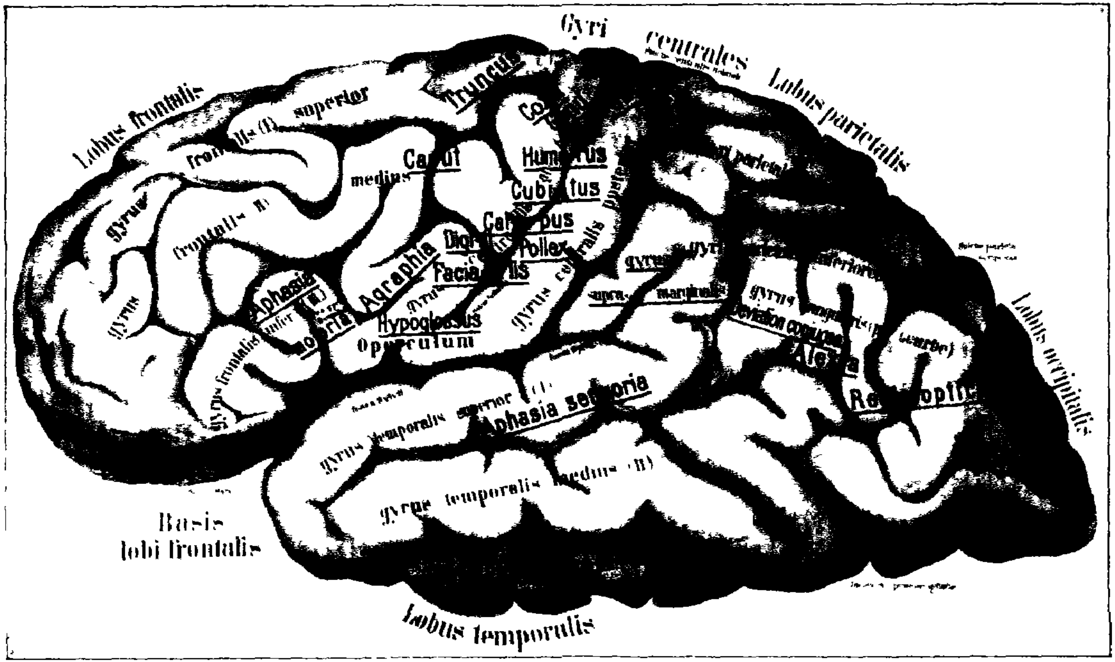

FIG. 13. — CORTEX FROM LEFT SIDE

Showing outer surface of left hemisphere. Front of head is at left of drawing. Lobes and convolutions as in Figs. 10 and 11. Centers for touch and movement (names underscored) run up the two central convolutions bordering the Rolandic fissure in the middle of the drawing (compare Fig. 14). Fissure of Sylvius (fossa Sylvii) runs horizontally near middle of the drawing. Language centers underscored. [From Strumpell and Jakob]

left, which contain the *primary centers* for stimuli from all the receptors. [Fig. 11.]

The Cortex. — The *cortex* is a thin sheet of gray nervous matter which lies above and around the basal ganglia, almost completely surrounding them.[1] The cortex and underlying portion of the cerebrum is divided by a deep medial fissure into two parts, called the right and left *hemispheres*, which are connected beneath by a mass of white fibers called the *corpus callosum*.

The surface of the cortex is covered with rounded creases, which give it the appearance of being wrinkled or folded. [Fig. 12.] Two deep creases on each side divide the cortex into readily distinguishable parts. They are called the *fissure of Sylvius* and central fissure or *fissure of Rolando*. [Fig. 13.] For convenience in reference, the regions marked off by these and the medial fissure are called *lobes* and are given separate names, though their functions are not always distinct. In each hemisphere there are four lobes; the frontal, temporal, parietal, and occipital.

The surface of the cortex is gray, covering a mass of white matter beneath.[2] This means that the cortex is made up largely of cell-bodies, while the part beneath consists of fibers leading to or from the cortex. The thin cortex is the final goal of the sensory fibers and incoming nerve impulses and it is the starting-point of the most highly organized motor impulses. The cortex is the great central control station of the nervous system.

There is no single dominating center in the cortex, where all incoming impulses gather and from which all motor impulses are generated. On the contrary, the cortex contains many separate receiving centers and many separate motor

thalami. In the illustrations of the brain the Latin names are used; the English equivalent is obvious in every case.

[1] The name *cortex* means bark or rind.

[2] Note that this arrangement is the reverse of the cord, where the gray matter lies inside the white.

centers. [Fig. 14.] The higher or control centers for sight (vision) and hearing lie in widely separated regions of the cortex. They connect with the lower or primary centers for these senses, which are situated in the optic thalami beneath. Near the cortical hearing center is a special center for audi-

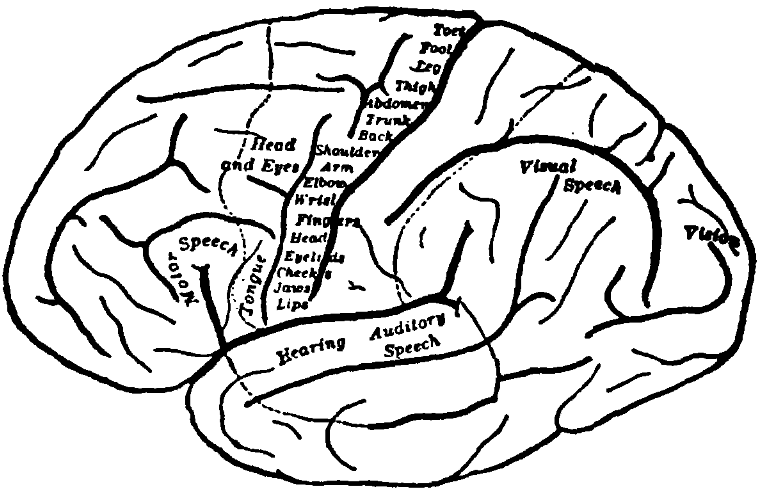

FIG. 14. — CENTERS IN THE CORTEX

Same view as Fig. 13. Diagram showing the touch and motor centers from toes to lips, and relation of language (speech) centers to centers for sight (vision), hearing, tongue, and lips. [From Herrick, after Starr.]

tory language — that is, for hearing and understanding spoken words. There are also special cortical centers for speaking, writing, and reading.

The arrangement of the cortical centers for touch and for moving various parts of the body is rather striking. [Fig. 14.] They lie along the fissure of Rolando, and are arranged in much the same order as the parts of the body which they serve: first, at the top, the centers for the toes, then for the foot, leg, thigh, and so on to the centers for cheek, jaws, lips. Notice that the order is inverted: the centers for the very lowest part of the body — the toes — are highest up in the cortex. The *motor* centers in this group lie on the *front* wall

of the Rolandic fissure; and just opposite each one, on the *rear* or posterior wall, lies the corresponding *sensory* (touch) center. In Fig. 14 the center for touch sensations from the toes lies just to the right of the center for moving the toes, and so on.

The cortical centers for sensory and motor functions which we have described are called *projection centers*, because the impulses are projected up from the primary sensory centers (and down to the primary motor centers) in the basal ganglia beneath. They are concerned not so much with the reception of sensory impulses as with combining and elaborating them. To take one example: the primary center for sight is in the thalami. A person gets visual impressions and is able to avoid obstacles in walking if the optic nerves leading from eyes to the thalami are intact, even though the visual center in the cortex is destroyed; but he cannot *recognize objects* without the cortical center for sight; and he cannot *read* if the word-seeing center is destroyed, though he can see the letters on the page as black marks.

Besides the projection areas, the cortex contains masses of connecting neurons. The regions in which they are located are called *association areas*. The association areas are filled with bundles of nerve fibers which form connections between the various projection areas. When you touch and see and smell a flower, all at the same time, the association fibers connecting the cortical centers for touch, sight, and smell are brought into play, so that these three impressions combine into the perception of a single object — the flower. In reading aloud the association fibers joining the word-seeing and word-uttering centers are used to connect the cortical process of understanding words with the cortical process of speaking. The cortical centers in one hemisphere are connected with the corresponding centers in the other by *commissure* fibers passing through the callosum.

In general there are corresponding centers for each sensory and each motor function in the two hemispheres. The corti-

cal centers for the right half of the body are in the left hemisphere, and vice versa. The visual centers form an apparent exception. The fibers from the left half of both eyes run to the left thalamus, and those from the right half to the right thalamus, half of each optic nerve crossing over at a place called the *optic chiasm*. But since the visual picture is reversed on the retina, the right half of each eye sees objects situated to your left, and vice versa, so that even here the law holds.

The four language centers (for speaking, writing, hearing words, and reading) are found in only one hemisphere — not in both. In right-handed persons the language centers are all in the left hemisphere of the brain. This is proved by cases of brain disease. If certain areas of the cortex are destroyed or injured, there is a language disturbance, *provided the injury is in the left hemisphere;* if the corresponding region in the right hemisphere is destroyed, there is *no* language disturbance, showing that there is no language area on this side.

Autonomic System. — The operation of the digestive organs, heart, lungs, and other internal organs is regulated by a system of nerves which do not form part of the main (or cerebrospinal) system. This is called the *autonomic system*. [Fig. 15.] It consists of a number of more or less independent groups of nerves, each of which has a small central mass of its own, called a *ganglion*. There are important nerve groups (called *plexuses*) belonging to this system in various parts of the body: at the base of the heart, in the upper abdominal cavity, and in the lumbar region. They control the circulation, digestion, and reproductive organs. There are also smaller ganglia in the head. Two series of ganglia are situated near the spinal cord, one on each side of the body. [Fig. 15; cf. Fig. 8.] Each of these ganglia connects with the next higher and lower ganglia, and with the neighboring spinal nerve.

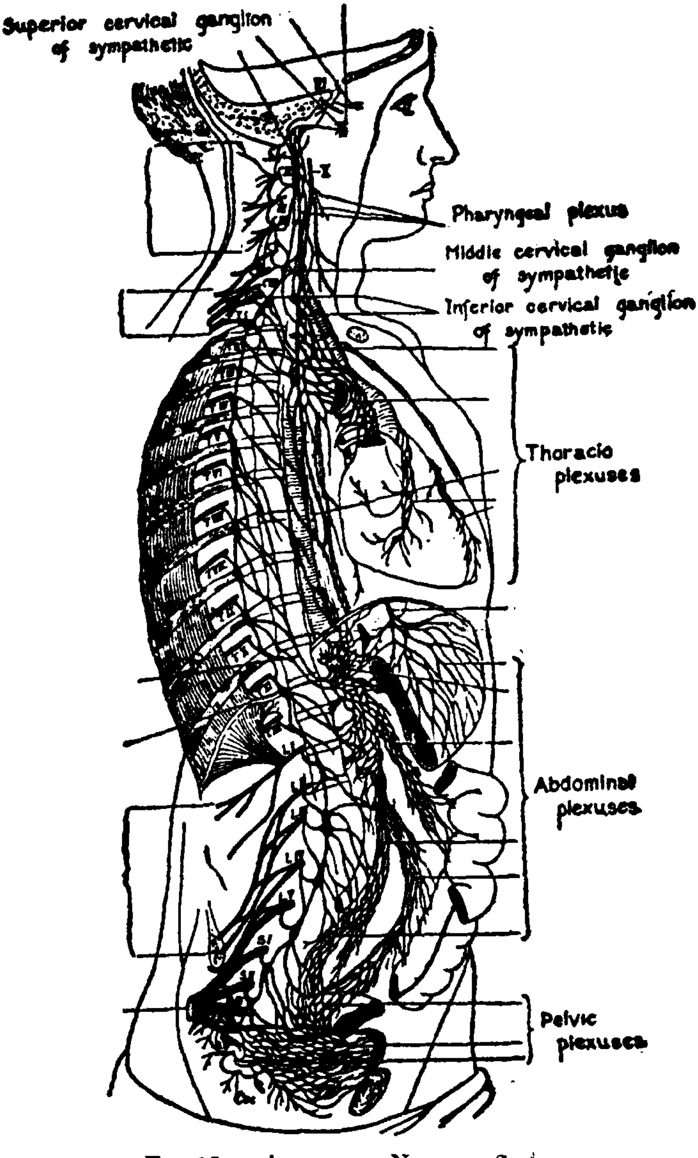

FIG. 15. — AUTONOMIC NERVOUS SYSTEM

Sympathetic ganglia and plexuses are shown in heavy black; numbering of autonomic ganglia corresponds to that of neighboring spinal nerves; C I = first cervical, T I = first thoracic, L I = first lumbar, etc. Compare Fig. 8. [From Lickley, after Schwalbe.]

The activity of the autonomic system governs the organic or biological life processes, so that usually these operate without conscious control. But the connection between the autonomic ganglia and the main nervous system makes possible an interplay between our organic and higher mental processes. By means of this connection, for instance, we are able to regulate our breathing, although breathing ordinarily goes on independent of brain supervision, by means of the autonomic system. In the same way our worries sometimes affect our digestion, through motor impulses from the brain which pass over into the autonomic digestive nerves. On the other hand, chronic indigestion often affects our temper or makes us depressed. In this case the autonomic system acts indirectly upon the cerebrospinal system: the digestive trouble causes toxic chemical products, which stimulate the organic senses and give rise to unpleasant sensations.

Summary. — The nervous system is composed of many millions of special cells called *neurons*. The distinctive features of the neuron are its long white axon fiber projecting from the gray cell-body, its collateral branches, its dendrites, and the minute fibrils in which all these terminate. Neurons connect together, end to end, by the intermeshing of this fibrillar network; the connection is called a *synapse*.

The nervous system is divided into the main (or *cerebrospinal*) and the *autonomic* system. The autonomic system is concerned chiefly with the bodily life processes — digestion, circulation, etc. It connects with the main system, however, so that our mental and bodily life processes influence each other.

The cerebrospinal nervous system consists of the *brain*, *cord*, and *peripheral nerves*. The *sensory* peripheral nerves lead inward from the receptors; the *motor* nerves lead outward to glands or muscles. The sensory nerves always carry impulses in from a receptor toward a center — never in the other direction. The motor nerves always carry impulses

out from the center toward the effector. Some peripheral nerves connect the end organs with the cord and lead to the brain through pathways within the cord; the cranial nerves in the head connect directly with the brain without passing through the cord.

The *cord* contains both conducting nerves and centers. The gray matter within the cord consists of cells which serve as centers for the immediate connection of incoming and outgoing nerves. These *spinal centers* cause quick, unconscious movements called reflexes. The knee-jerk is a spinal reflex. The white matter of the cord surrounds the gray matter; it consists of masses of sensory fibers which continue the sensory paths on toward the brain, and motor fibers connecting the brain with the peripheral motor nerves.

The *brain* comprises all higher nerve centers, where sensory nerves connect with other sensory nerves, motor with other motor nerves, and sensory with motor nerves. The *cerebellum* lies at the base of the brain, and contains a system of centers for regulating our equilibrium and general posture. Above this lies the *cerebrum*, or great brain, consisting of basal ganglia and cortex. The *basal ganglia* contain the lower control centers for receiving impulses from the receptors.

Surrounding the basal ganglia is the *cortex*, divided into two *hemispheres*, which acts as the highest controlling station of the system. In it are the *projection centers* for incoming and outgoing impulses, and *association areas* for connecting these together. The cortex contains many million neurons. Our highest intelligent activities, such as perception, language, thought, and voluntary movements, depend on the intricate connections of neurons in the cortex.

PRACTICAL EXERCISES:

6. Report any instances of indigestion or other bodily disturbance due to anxiety or disappointment.
7. Describe any brightening of your outlook on the world due to improvement of your bodily condition; or depression caused by bodily ailment.
8. Test the involuntary eye-wink of some friend by an unexpected loud

noise or quick movement past the eye; note the voluntary resistance to the wink when the experiment is repeated several times. Report the experiment, including his description of the experience. Test the iris reflex with a flash-light in a dark-room.

9. Describe (or name) the different sorts of muscular movement which you can observe in your face and head.
10. Make a sketch of the cortex of the left hemisphere, indicating the various centers.

[Exercises 6 and 7 are on the relation between the cerebrospinal and automatic systems; 8 is on the reflex nerve paths; 9 is on the motor-nerve terminals; 10 is on the topography of the brain.]

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CHAPTER III

OPERATION OF THE NERVOUS SYSTEM

How the Nervous System Works. — Despite the complexity of the nervous system, its general manner of operation is simple: (1) Some one of the receptors is stimulated. (2) The stimulus starts a *nerve impulse* in the sensory neuron connected with this receptor, and this impulse travels along a sensory path to a center in the cord or brain. (3) Impulses which reach the sensory centers at the same time are collected and combined with the traces left by previous impulses and proceed to a motor center. (4) A motor impulse goes out from the motor center along some motor nerve to a muscle or gland. (5) The muscle contracts and a bodily movement occurs, or if a gland is affected, secretion results.

This entire circuit is called a *nervous arc.* Nerve energy always passes through a nervous arc, and always in the same order. A concrete example is the way the nervous system operates when a man tries to catch a baseball.[1] (1) The light waves from the ball reach the player's eye and stimulate it. (2) The optic nerve carries the effect to the visual center in his brain. (3) In the brain the impressions from all parts of the ball and the background around it are put together. The resulting picture is combined with other impressions received at the same time and with the player's memories; then a nerve impulse goes to the brain centers for arm and hand movement. (4) The motor nerves thereupon carry nerve impulses down from the brain through the cord and out to the muscles of the arm and hand. (5) When the impulse reaches these muscles it causes them to contract. The ball is caught if the motor impulses are well coördinated. If the brain coördina-

[1] See Fig. 2, p. 4.

tion is poor, the muscles do not contract just right and the player misses or fumbles the ball.

In some cases the process is simpler and in others much more complicated than this. *Winking* is the result of a very simple nervous operation. When an object passes close to your eye, the eye is stimulated very suddenly. The sensory nerve impulse in the optic nerve goes only to the lower visual center. No time is lost in collecting or distributing: the impulse passes directly over to the center for lowering the eyelid; the motor impulse goes out to the eyelid muscle *at once*, and you wink. These very simplest nervous activities are called *reflexes*. Winking is a *cranial* reflex; its arc lies within the head.

There are other simple arcs which do not enter the head at all; they are called *spinal* reflexes. [Fig. 16.] When something unexpectedly touches the skin of your hand, a sensory impulse is carried by the sensory nerve to the cord. There it passes over from the dorsal to the ventral part of the gray matter (on the same side of the body), and passes out along the motor nerve to the muscle in your arm; the muscle contracts, and you jerk your hand away.

Many human actions are very complicated and involve an intricate nervous arc. Suppose you are going to answer a letter. A large number of stimuli affect you as you read the message. When they reach the brain you do not start to write at once, but you *think it over;* that is, there is a period in which nerve impulses are traveling from center to center in the brain, arousing memory pictures and thoughts. After a time your thoughts are satisfactorily marshaled, and it is then that the motor impulses from the writing center begin to flow out to the muscles of your fingers and wrist.

In every case, whether simple or complicated, the nervous activity consists of a succession of five steps: (1) *Stimulation* of a receptor; (2) *conduction* of nerve impulses toward a center; (3) *adjustment* of impulses at the center or centers;

(4) *conduction* of motor impulses to an effector; and (5) *response* or activity by the effector. Each of these steps must be examined before we can understand the process as a whole. We may combine the two conduction processes and discuss the questions in the following order:

What is stimulation?
What is nervous conduction, and what are the other characteristics of the nerve impulse?
What is response?
What happens at the nerve centers?

Stimulation. — Stimulation is the effect produced on a receptor by some object or force in our surroundings (environ-

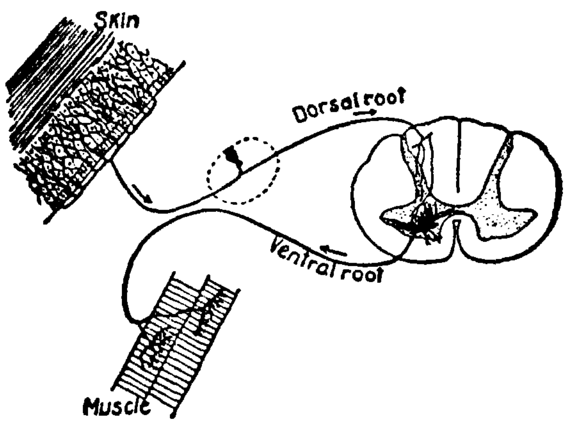


FIG. 16. — NERVOUS ARC IN SPINAL REFLEX

Showing path of reflex nerve impulse when the skin of hand is stimulated. A sensory impulse travels in direction of arrow to the cord, entering at the back (dorsal root); the impulse crosses immediately to front of gray matter; thence a motor impulse goes out through the ventral root to muscle in the arm, producing muscular contraction. [From Herrick, after Van Gehuchten.]

ment) or within our body. When you touch a book or an apple before picking it up, the surface of the object presses against your skin and quickly produces a change in certain receptors called *touch corpuscles,* which lie scattered about in the skin; that is, the pressure on the skin *stimulates* these

corpuscles, and the effect is communicated to the endings of sensory neurons which lie in close connection with the touch corpuscles. When light waves from an object stimulate your eye the effect is communicated to the neurons of your optic nerve in a similar way. In the case of touch the stimulus is a material body; in the case of sight the stimulus is a force. The stimulus acts in a *mechanical* way on the receptor in touch and hearing; in certain other senses, such as sight and taste, the stimulus produces a *chemical* change in the receptor.

The stimulus may act either from inside or outside the body. Hunger is caused by stimulation of the receptors in the lining of the stomach and alimentary canal. Here the stimulus is *inside* the body. The muscle-sense stimulus is also inside the body. When you bend your arm the muscle-sense receptors are stimulated by the change in muscular tension and this starts the nerve impulse which gives you a sensation of movement. In the case of sight, hearing, smell, and touch the stimulus is *outside* the body, in the surrounding world, and acts upon receptors situated at or near the surface of the body.

Nerve impulses do not start themselves; they do not originate in the neurons. They always depend on some stimulus which works upon a receptor organ, such as the eye or touch corpuscles; this effect is transmitted immediately to the sensory neurons whose endings are in close connection with these receptors. There is one partial exception to this rule. The nerves which give us pain sensations have no receptor organs. Pain is caused by wear and tear of the tissues of the body; the destruction of tissue is a stimulus which works directly on the sensory nerves for pain. This means merely that in the case of pain there is not a *double process* of stimulation. In all other cases the stimulus affects the receptor and then the receptor affects the sensory nerve.

The nature of the impulse in the sensory nerve is deter-

mined in the first instance by the nature of the stimulus. The *intensity* of the impulse is determined by the intensity or force of the stimulus. The brighter the light which strikes the eye, the more intense is the resulting impulse in the optic nerve; the greater the pressure of an object on the skin, the more intense is the resulting impulse in the nerve for touch. The *quality* of the stimulus also determines the impulse in certain cases. The different light waves which strike the eye produce differences in the nerve impulse, which enable us to distinguish colors.

The sensory impulse depends also on the nature of the *receptor*, and how it is affected by the stimulus. A well-developed eye is capable of distinguishing more differences of intensity and more colors than an eye of the primitive type found in very low animals. A human being can tell more readily than a starfish that it is getting lighter or darker. This is because the human eye is more perfect; its reactions to light are more finely graded. Consequently the human eye passes on to the optic nerve a greater variety of different effects, and these differences are transmitted to the brain; so that man is able to detect much finer gradations of light than the starfish.

In point of fact, the receptor has more to do with determining the form of the nerve impulse than the stimulus. If two coins, a cent and a nickel, be placed one above the other beneath the tip of the tongue, so that they touch the tongue and each other, we get a peculiar metallic taste sensation. Neither coin separately can be tasted. There is no taste stimulus properly speaking, but chemical action (electrolysis) is set up by their connection with the tongue. The electrolysis stimulates the taste receptors and this sets up a nerve impulse in the taste nerve. In other words, the impulses set up in any sensory nerve are determined not merely by the stimulus, but by the make-up of the receptor. Whatever the stimulus, the impulse is specific to the receptor stimulated: the taste

receptors always give us tastes, the eye always gives us sensations of light, — if they give any sensation at all.

The Nerve Impulse. — The exact nature of the nerve impulse is not yet known. This is because the neurons are very small and their activity cannot readily be observed. We know that nerve conduction is not a flow of material, like the passage of water or gas through a pipe. We also know that the nerve impulse is always accompanied by an electric current; but it is uncertain whether this electric current *is* the nerve impulse. There is certainly some chemical action in the neuron during the passage of the nerve impulse, and possibly the nerve impulse is really a chemical change in the nerve substance. In other words, the nerve impulse may be electrical, or it may be chemical, or it may be a combination of the two. Until physiologists have settled the question definitely, psychologists must be content to call the nerve impulse a *chemico-electric event*, which covers all three possibilities.

Properties of Neurons: Excitation and Conduction. — The substance which composes the neurons has a number of characteristics or properties; its two fundamental properties are *excitation* and *conduction*. *Excitation* means that a neuron is capable of being aroused into activity by some force acting upon its fine branching ends. A peripheral sensory neuron is *excited* by the receptor, as a result of stimulation. Every other neuron in the arc is excited or aroused to activity by impulses from some other neuron which connects with it at a synapse.

Conduction means that a neuron, when once it has been excited at one end, transmits the impulse along its main fiber and branches to the synapses at its farther end. *Conduction takes place only in one direction.* The impulse always proceeds *towards* the center in sensory nerves and *away from* the center in motor neurons. This is due to the construction of the synapses. They are so made that the impulse can pass

through them in one direction only — like the entrance to a mouse-trap. The synapses of the collaterals follow the same principle. They transmit impulses in one direction only.

The result of this law of conduction is that all impulses tend to proceed from receptor to center and from center to effector. There is no 'back-wash' in the reverse direction.

Retention and Fatigue. — The course of the nerve impulse along the arc is not always the same. The path which a given impulse takes depends upon physiological conditions in the neurons and synapses. There are two properties of the nerve substance which determine and alter the course of the impulse: *retention* and *fatigue*.

Retention means that if an impulse in a certain neuron has once passed over a given synapse, that synapse thereby becomes a less resistant or more permeable pathway; that is, in future, similar impulses along this neuron are more likely to pass out through this particular synapse than through another. It also means that every nerve impulse leaves a *trace* of some sort in the nerve substance, which has an effect on future impulses passing along the same neurons. For instance, when we look at a printed page the black and white of the printed background stimulate a great many separate neurons; after the impulse has passed on, the neurons retain a trace or permanent impress, which influences any subsequent impulses passing through these same neurons. This permanent 'set' or 'mold' is the basis of memory, one of the most important facts in mental life. The retention traces or set left in certain central neurons by the letters and words we have read, make it possible for us in future to recall our former experience of reading these words — to get a mental image of the same words and sentences long afterwards, without consulting the book.

The persistence of retention is readily observed in the case of motor habits, such as swimming or bicycle riding. If you once acquire one of these habits, it can be revived after a

long lapse of time with very little practice. The same is true of mental habits. If you memorize a poem by repeating it over and over again, you will find that you can recall it after a long period during which it has apparently been forgotten.

Fatigue is an effect which is the opposite of retention. It means a *loss* of efficiency. Through constant use of the same neurons and synapses there comes about a wear and tear of substance, which impedes the nerve impulse. This effect is similar to the fatigue that occurs in the receptors and muscles. If you look steadily at a bright object, the eye is fatigued; if you carry a heavy suitcase, the muscles of the arm are fatigued. The efficiency of the eye or the muscle is temporarily impaired. Just so the synapses in the nervous system become fatigued if we use the same nervous arcs constantly. A fatigued synapse offers more resistance to the passage of impulses; if the resistance is very great the impulse is unable to pass through that synapse at all and is shunted over another synapse into another path. This accounts in part for the variety of our actions. If the synaptic connections grew continually more and more fixed, we would in time have only a lot of stereotyped habits.

The fatigue effect occurs only when the same neurons are used steadily, with no let-up. If the stimuli are varied, the synapses have a chance to rest, the nerve substance is gradually restored, and the fatigue finally wears off. This is quite different from the retention effect, which persists in spite of the lapse of time.

This explains why we become fatigued after studying the same subject for a long time without intermission. By changing our mental work to something quite different, we rest the brain and can accomplish more.

Collection and Distribution. — These are two other characteristics or properties of the nerve impulse. *Collection* is the gathering together of several impulses into a single neuron. [Fig. 17.] When we look at any object, a great number of

nerve impulses are started along the various fibers of the optic nerve and proceed separately to the visual center of the brain. Here the separate impulses are gathered together, so that we see the object as a single thing. All our perceptions of objects and events are due to the collection of many separate impulses.

Distribution is the opposite of collection. Nerve impulses do not always proceed along a single pathway. Often they pass out of a neuron by several synapses at once, into as many different motor paths. [Fig. 18.] Whenever you perform a

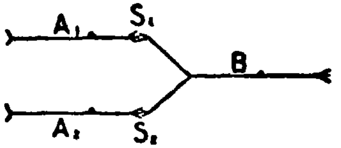


FIG. 17. — COLLECTION OF NERVE IMPULSES

Nerve impulses in two separate neurons A_1, A_2, passing through synapses S_1, S_2, enter the same neuron B and proceed onward as a single complex nerve impulse.

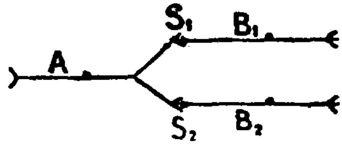


FIG. 18. — DISTRIBUTION OF A NERVE IMPULSE

The nerve impulse in neuron A divides and passes out through the synapses S_1 and S_2 into two separate neuron paths B_1 and B_2.

complicated movement, involving several muscles, distribution of the motor impulse takes place. When you grasp a stick, all your fingers work at the same time. If you watch the movement carefully, you will see that the several joints of each finger bend at once; there may be a wrist movement also. This complicated movement is brought about by the distribution of the nerve impulse from a motor center into a number of motor neurons leading to different muscles.

Distribution may also occur in the sensory nerves. When you are startled by a sudden noise, the nerve impulse is distributed; part goes directly into the motor nerves and causes the reflex movement of jumping or 'starting'; the rest of the impulse passes up to the higher auditory center and enables you to hear the noise.

Importance of these Properties. — The six characteristics

just described are properties of neurons and nerve substance. They indicate just what different operations the nervous system can perform. The stimuli and receptors furnish certain material for the use of the nervous system: light waves strike the eye; sound waves affect the ear; pressure stimulates the touch corpuscles, and so on. How does the nervous system use this material? It is able to make use of the stimuli in the following ways: (1) The neurons are *excited* in various ways, according to the quality, intensity, and duration of the stimulus. (2) The impulse caused by the stimulus is *conducted* along the peripheral sensory neuron to the next neuron, and so on through the entire nervous arc to the effector. (3) The effect of an impulse is *retained* for future use, through the trace or set which it leaves in the nerve substance. The route of an impulse in the nervous arc is in part determined by the traces left by former impulses. (4) Synapses become *fatigued* through constant use, which makes possible a shunting of the impulse into other paths, giving variety to our experience and actions. (5) Impulses from several neurons are *collected* or gathered together into a single neuron, producing complex nerve impulses and unified experiences. (6) An impulse may be *distributed* into several different motor neurons, which makes possible the performance of coördinated movements.[1]

These properties belong not only to the individual neurons, but to the groups of neurons called nerves, and in fact to the nervous system as a whole. If you examine your own everyday experiences, you will find that they all depend partly upon the stimulation of your eyes, ears, skin, and other receptors, partly upon the properties of the nervous system just described. Memory, perception, in fact every event of mental life, can be described in terms of these fundamental properties.[2]

[1] Another property, less important, is *modification*. When several impulses combine they may undergo changes of quality.

[2] This will be brought out more fully in ch. vi.

Response. — A response is the effect produced by nerve impulses upon the muscles and glands, together with the bodily movements and changes brought about by muscular and glandular activity.

Winking is an example of a simple response; it involves only the muscle of the eye-lid. Grasping with the hand is more complex; it is brought about by nerve impulses from the centers to the muscles of all the joints of the fingers and thumb. Most of our common acts are very complex responses. Take the act of reading aloud. The stimuli are the printed words on the page. A very intricate series of nerve impulses is set up when you look at the letters, and the final result is a succession of vocal utterances due to contraction of the muscles of your throat, lips, cheeks, and thorax. Many human responses are even more complicated than this. When a man goes out from his home town to set up in business or engage in a profession elsewhere, his 'going' is a response to a tremendous number of stimuli that have acted on him, often for a number of years.

Our actions are called *responses* because they are our answers to situations in which we are placed, and which are made known to us by stimuli from the environment affecting our receptor organs. All movements which are produced through the activity of our nervous system are due directly or indirectly to stimuli. No nerve impulse is started inside the nervous system; every nerve impulse originates in some stimulus which works upon our receptors and sensory nerves. Even our voluntary actions are responses to situations in the outer world; these situations are reported to the brain by sensory nerves, and arouse perceptions and thought, leading finally to volition.

The term *response* as used in psychology applies only to movements or changes brought about by the action of the individual's own nervous system. If we stumble over a wire and fall, the falling movement is not a response; but the wild

gestures we make in trying to save ourselves are responsive in character. When a convict is taken to prison, his going there is not a response, psychologically speaking, though each of the steps he takes may be a separate response. Going to prison may be a *social* response, and falling down is certainly a *physical* response, but neither of these is a *psychological* response. Psychology is concerned only with actions which are brought to pass through the workings of the nervous system.

Responses are of two sorts — muscular and glandular. *Muscular responses* are due to contraction of the muscles. [Fig. 19.] When a motor nerve impulse reaches the muscle it causes a chemical change in the muscle fibers, which

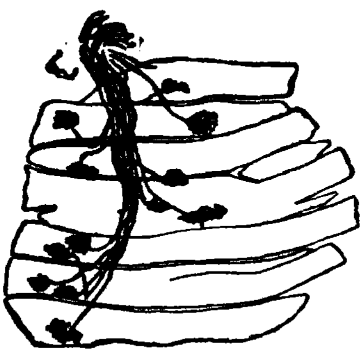


FIG. 19. — MUSCLE WITH NERVE ENDINGS

The long horizontal strips are strands of muscle fibers. The dark vertical lines are motor nerve fibers which terminate in the several strands. Nerve impulses cause the strands to contract — they become shorter. [After Dunlap.]

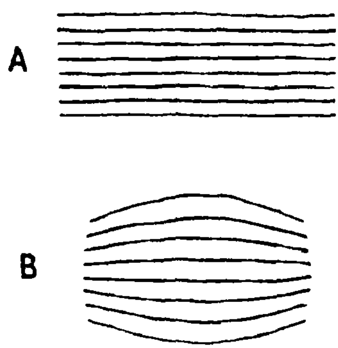


FIG. 20. — DIAGRAM OF MUSCULAR CONTRACTION

A. Strands of an uncontracted muscle.
B. Same muscle when contracted. The strands are shorter, the muscle is thicker in the middle.

shortens them lengthwise; the ends are brought nearer together. The muscle is thickened in the middle at the same time. [Fig. 20.] One end of the muscle is often fastened to a bone which plays in a socket, so that when the muscle contracts the bone turns like a hinge.

Muscles usually go in pairs. The *flexor* muscle bends the arm at the elbow, the *extensor* straightens it. Such a pair are called *antagonistic* muscles. The name is somewhat misleading, for the two antagonists usually work together splendidly. When one contracts the other relaxes, so that the arm or finger or other member bends at a regular rate and is held securely in position all the time by the pair.

A muscle may be contracted at various rates of speed. These differences depend on the intensity of the nerve impulse. A quick bending of the finger is brought about by an intense motor impulse; a very slow movement occurs if the impulse is weak but continues to operate for some time. Differences in quality of the nerve impulse have not the same importance in motor nerves as in sensory nerves. The muscular contraction is the same whatever the kind of impulse.

In addition to the motor nerve endings there are *receptors* and sensory nerves in the muscles. These report to us how the contraction is progressing. When you are bending your finger you know all the time how the finger is moving and how much it has moved, even without looking. These muscle sensations enable you to regulate the response. If you start to lift a box and it is heavier than you thought, the sensory nerves in your arm muscles report to you the amount of resistance and the fact that the movement is slow. Thereupon a more intense motor impulse is sent down to the muscle and the movement is speeded up.

Glandular responses are not so important in mental life as muscular responses. The glands are more concerned in growth and in maintaining the body than in responses to the environment. When the glands take part in our responses it is generally in a subsidiary way. In extreme emotion we weep — a response by the tear glands. Anxiety sometimes affects the sweat glands. The sight of a luscious peach produces activity of the salivary gland; the mouth waters. It has been found also that certain emotions operate on the

ductless glands inside the body, though these glands are chiefly concerned with nutrition and growth. Fear brings about the production of chemical substances (such as adrenalin) in the body, which affect our general bodily condition.

The ordinary operations of the glands are not part of the response; in general, the secretion of saliva, urine, sweat, tears, etc., are part of our bodily life-processes and are of no special concern to psychology.

Central Adjustment. — In chapter i, the brain was likened to a telephone exchange, where wires come in from every direction and are connected up with a vast number of other wires. It may also be likened to a great switching-yard, where freight trains come in and are broken up, some cars going to one destination, some to another. Both of these analogies are imperfect, for nerve impulses travel along any given nerve only in one direction: in the sensory nerves the impulses always proceed *inward*, toward the cord and brain, while along the motor nerves they only travel *out* from the brain and other centers. Also, many impulses are always coming in from all directions at once, and many complicated motor impulses are being sent out, all at the same moment. But the main point in the two analogies is correct: the brain is a great receiving, switching, and distributing center — with *many thousand times* more connections than exist in any telephone central or railroad freight-yard.

The brain centers and the lower centers in the cord are the regions where the nerve impulses from the receptors are switched over to the motor nerves and sent out to the effectors. In addition the brain centers *collect* many sensory impulses and *distribute* impulses to many motor neurons. Both of these processes are of the utmost importance.

The collection of nerve impulses in the brain is called *integration.* It is more than a mere addition process; the separate impulses are put together in such a way that their relations closely resemble the relations along the stimuli.

When we look at a landscape the integrated affect of the visual impulses in the brain is like the landscape outside of us which stimulates our eyes and optic nerves at the moment. The resulting picture or *perception* of the landscape — the way it appears to us — is like the real landscape in form. This is due to the integration of separate impulses from a large number of nerve fibers in the visual center. We see things for the most part as they actually are. The same is true of hearing, touch, and other sense impressions.

In looking at a landscape you will notice that some objects are *featured* — they stand out and attract our attention. This means that the nerve impulses are not collected uniformly. Some are reinforced and others are weakened, so that the various parts of the visual field are of different vividness — they receive different emphasis. When you are reading an interesting story you do not hear the conversation going on around you. The impulses coming through the ear reach the brain, but they are almost shut out from the general assembly of your impressions at the time. Here again some of the impressions are featured at the expense of others.

Integration is the *systematic assembling* and marshaling of all the impulses which reach the brain at a given moment. In the integrating process some elements are focused and others are scarcely noticed. This selective character of integration is an important factor in the regulation of responses. If you are gunning, the great idea is to hit the partridge — not to shoot up the landscape generally. You must pick out the bird from all other details of the scene before you can respond properly. This is accomplished by the integration of sensory impulses in your brain.

The other important feature of the brain's work is the proper distribution of motor impulses. This is called *coordination*. It is one thing to see your bird, and quite another thing to wing him. When you raise the gun, the various muscles of your shoulder, elbow, wrist, and finger joints must

be contracted just so much and no more. If you continue the motor impulse to any of these muscles too long or press the trigger too soon, you miss your shot. In order to perform any complex response correctly, the brain must start a number of impulses along different motor paths at the same time, and each impulse must be regulated to the proper intensity and must continue just so long. Coördination involves all this. It is more than mere distribution — it means *systematic* distribution.

One generally thinks of his movements and voluntary actions as being performed by his muscles. As a matter of fact the muscles are merely our agents. They are controlled by our brain centers. Coördination is a brain process, not a muscular process. It is a question of sending the right motor impulses out from the brain to the right muscles at the right time.

The two processes of integration and coördination work together. All our responses to stimuli, except in the very simplest cases, involve them both. Most of our actions depend on a great number of changing stimuli and are accomplished by a series of complicated movements. We must learn to fit the response to the situation. This means integration of all the stimuli and coördination of all our motor activities. The systematic combination of integration and coördination is called *adjustment*. We are continually adjusting our actions to constantly changing situations.

The hunter shooting at the bird is a case of adjustment. Until he sees the bird there is no impulse to pull the trigger. For a time he sees all sorts of other objects in the landscape. Suddenly he spies the bird; the perception is due to an integration of many stimuli from the retina of the hunter's eye. At once the nervous activity in the hunter's brain passes over to motor centers and out through various motor nerves to his arm and fingers, so that he lifts the gun and pulls the trigger. The adjustment process here includes the *integrated percep-*

tion and the *coördinated motor impulse*, both of which take place in the brain. Adjustment is the most important feature of mental life.

It is important to keep this in mind in reading the following chapters; we shall take up a great many special topics: sensations (the elementary impressions derived from stimuli), experiences of various sorts, and different kinds of behavior. These separate facts are simply fragments of our mental life. Mental life as a whole is a continuous succession of stimulations leading to responses. The significant part of the process is the *central adjustment of the response to the stimulus.* Mental life is not the fact that we see, or that we act, but the fact that our actions are adjusted to what we see; the adjustment takes place in the brain.

Summary. — The nervous system serves as a network of pathways over which nerve impulses pass from the receptor organs through the centers to the muscles and glands. The nerve activity starts with *stimulation* of a receptor. This produces an *impulse* in the sensory neurons which travels along the sensory paths to sensory centers in the cord and brain. In the sensory centers impulses are *integrated* and pass over to motor centers, where *coördinated* motor impulses are set up in the motor nerves. The *motor impulse* travels along motor paths to the appropriate muscles or glands, and discharges its energy into them; the activity of these effectors constitutes a *response*.

The nerve impulse varies in intensity and quality, these two characteristics being determined in the first place by the nature of the stimuli and receptors. There are also certain properties of the nerve substance which determine what the impulse shall be, over and above the stamp which it receives from the stimulus. These properties are *excitation*, *conduction*, *retention*, *fatigue*, *collection*, and *distribution*.

The activity of the nervous system proceeds through a circuit or arc from receptor to effector. Each arc is composed

of three sections: *sensory*, *central*, and *motor*. Corresponding to these there are three phases of activity: *stimulation*, *adjustment*, and *response*. The adjustment process is the most important of all. It includes *integration* of sensory impulses, and *coördination* of motor impulses. Integration and coördination work together and tend to make our responses appropriate to the total situation at any given time. Adjustment is the most significant fact of mental life.

PRACTICAL EXERCISES:

11. Describe one of your earliest definite recollections of childhood. How old were you when it occurred? Can you tell why the recollection has persisted?
12. Try to memorize a definition when sleepy. Compare this with memorizing when you are fresh and wide awake.
13. Practice keeping a ball tossing in the air with a tennis racquet. Notice the adjustments of your own movements to the different angles of the falling ball, and describe the experience.
14. Study several cases in which you can readily perform two independent actions at once, and other cases where one action interferes with another. Compare them and determine if possible why they coöperate or interfere.
15. Observe a child trying to use knife and fork or fold a napkin. Describe any lack of coördination that you notice.

[Exercise 11 is on retention, 12 is on fatigue, 13 on adjustment, 14 and 15 on coördination.]

REFERENCES:

On the nerve impulse: K. Lucas, *Conduction of the Nervous Impulse.*
On the operation of the nervous arc: C. S. Sherrington, *Integrative Action of the Nervous System.*

CHAPTER IV

THE SENSES: SIGHT

The Receptors and Sensation. — We have seen that mental life depends upon nerve impulses which are started by activity in the receptor organs. All our experiences and actions may be traced to some stimulation of these organs by objects or forces outside our body or by conditions within the body. Before taking up the study of perceptions, memories, thoughts, and other sorts of experience, we must examine the simple elements of which every experience is composed, and which are aroused by the activity of the receptors and sensory nerves. These mental atoms which combine into experiences are called *sensations*.

The receptors are commonly known as *sense organs* or *senses*. Formerly man was supposed to have only five senses — that is, five distinct sense organs, each giving a different sort of sensation. Popular psychology and poetry still recognize only the senses of sight, hearing, taste, smell, and touch. Scientific investigation has shown that there are several more. At present we can distinguish eleven senses, with the possibility that some of these may be subdivided still further. [Table I.]

The senses fall into three groups: (1) the *external* senses, which are stimulated by objects outside the body; (2) the internal or *systemic* senses, which are stimulated by conditions within the body; and (3) the *motor* senses, which are stimulated by our movements and bodily position, and depend on both the outer world and our own body. The external senses fall into two subgroups: (*a*) *distant* senses, which are affected by stimuli usually originating in objects situated some distance away from our body, and (*b*) *con-*

tiguous senses, which are stimulated only by objects in immediate contact with the body.

TABLE I. — CLASSIFICATION OF THE SENSES

Class	*Sense*	*Receptor*	*Kinds of Sensation*
1. External (a) Distant	Sight	Eye	Colors and grays
	Hearing	Ear	Tones and noises
	Smell	In nostrils	Odors
(b) Contiguous	Taste	In tongue	Tastes
	Touch	In skin	Contact and pressure
	Warmth	In skin	Warmth
	Cold	In skin	Cold
2. Systemic	Organic	In internal organs	Hunger, fatigue, sex, etc.
	Pain	Free nerve endings	Pain
3. Motor	Kinesthetic (muscle sense)	In muscles	Effort, strain, etc.
	Static	Semicircular canals, sacs	Position, rotation, etc.

Sight is a distant sense. The things that we see are often far away. In reading, we hold the book several inches from the eye. The sounds that we hear and the odors that we smell are from sources some distance off. In every case the stimulus must reach the receptor before it can start a nerve impulse and cause a sensation. But in the case of the distant senses the stimulus is a wave or emanation from some object which does not itself come into contact with our body at all. By means of these senses we gain information about things that lie at a considerable distance from the body. This is extremely important, for it widens our field of experience tremendously: our environment is extended as far as we can see, and hear, and smell. One who is both blind and deaf has a very limited environment compared with the normal human being.

1. SIGHT (VISION)

The Eye. — The receptor for sight is the eyeball, together with the muscles attached to it, which enable it to move.

The eye is a nearly spherical body. [Fig. 21.] Its outer

coating is a tough substance called the *sclerotic*, which covers all the sphere except the extreme front surface. The sclerotic

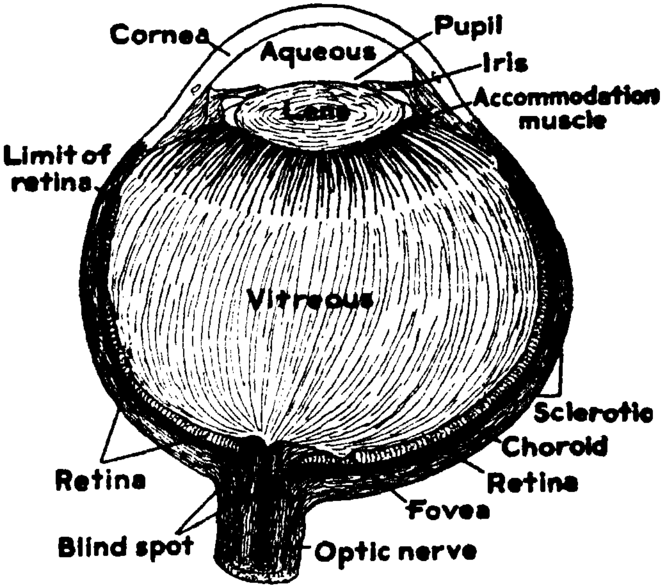


FIG. 21. — CROSS-SECTION OF EYE

Horizontal section through right eye, viewed from above. In left eye the optic nerve pierces the retina at the right of the fovea.

is almost impervious to light. The front surface of the eyeball is covered by a transparent coat called the *cornea*. Light passes readily through the cornea, just as it does through a window-pane.

Looking at the eye from the front, we observe back of the cornea a transparent oval body called the *lens*. The lens is convex on both surfaces, like a camera lens, and focuses the light waves on the rear inner surface of the eyeball. The lens is held in place by a ring-shaped muscle at its edge, which serves also to change its shape. When this *accommodation muscle* contracts, it squeezes the lens so that it bulges out; this changes the focus. The space between the lens and

cornea is filled with a transparent liquid called the *aqueous humor*, which permits the bulging of the lens.

The *iris* is a flat muscle situated just in front of the lens. It resembles a disk or circular curtain with a large hole in the middle. The iris is opaque, and serves to regulate the light entering the eye, like the diaphragm of a camera. No light can reach the lens except through the central hole of the iris. This hole is called the *pupil*. Bright light causes the iris to contract, so that the opening becomes smaller, and less light is admitted. When we go into a dark room the iris relaxes and the opening becomes very large; more light is admitted into the eye and we see more clearly.[1]

Behind the lens, filling most of the interior of the eye, is a tough, transparent, jelly-like substance called the *vitreous body*, which prevents the lens from slipping backward.

Back of the vitreous, forming the inner surface of the eyeball, is the *retina*.[2] [Fig. 22.] The retina is a thin woven coat composed of a network of cells and tissues of various sorts. It consists of ten layers, the most important of which is the layer of *rods* and *cones* (marked 9 in the figure).

The rods and cones are the real receptors for visual stimuli. They are exceedingly small — from 0.002 to 0.006 mm. in diameter.[3] Each rod and each cone is connected with a neuron of the optic nerve. The cones are shorter and thicker than the rods; the two can be easily distinguished in the figure. If we take a tennis ball, cut away about a third of it, and look *inside* the remainder, what we see corresponds to the area in the eye covered by rods and cones. They are crowded together all over the inner lining except in front.

Looking at the surface of the retina, four regions should be

[1] A cat's eye is extremely sensitive to light. Notice that the pupil contracts to a thin line in bright daylight; in the dark it becomes very large. This is why a cat can see quite well when there is very little light.

[2] Between the (outer) sclerotic coat and (inner) retina is a third coat called the *choroid*.

[3] A millimeter is about one twenty-fifth of an inch.

noticed: the *center*, the *blind spot*, the *intermediate field*, and the *periphery*.

(1) CENTER OF RETINA: The center of the retina lies at the 'opposite pole' of the eyeball from the center of the pupil.

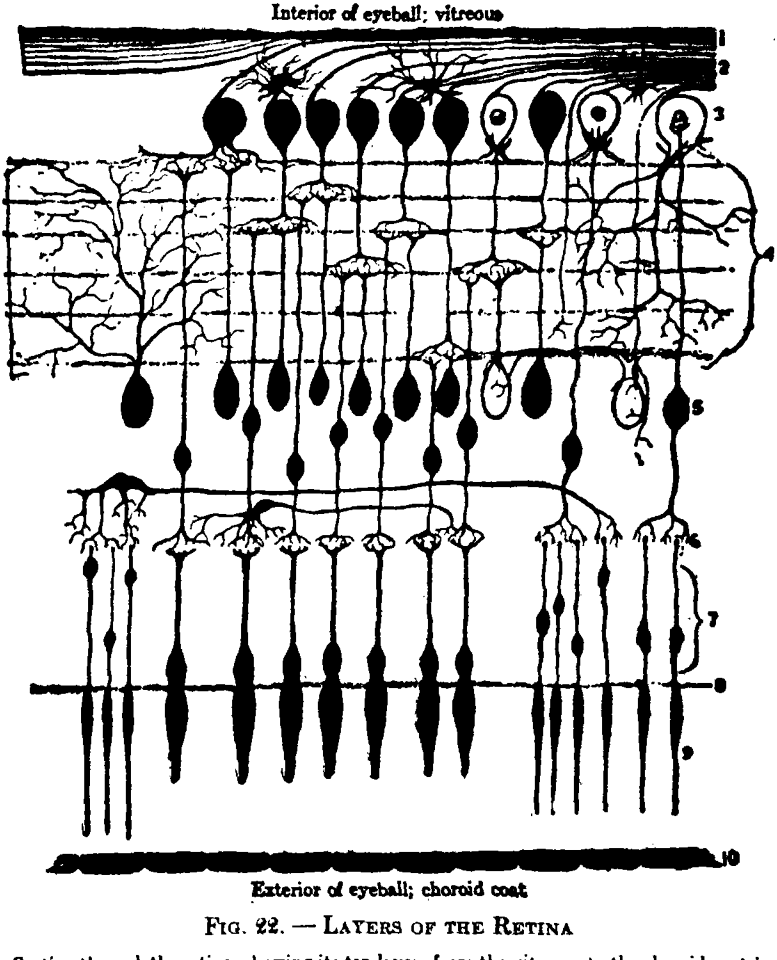


FIG. 22. — LAYERS OF THE RETINA

Section through the retina, showing its ten layers from the vitreous to the choroid coat just inside the sclerotic: (1) inner limiting membrane, next to vitreous; (2) layer of nerve fibers; (3) layer of nerve cells; (4) inner molecular layer; (5) inner nuclear layer; (6) outer molecular layer; (7) outer nuclear layer; (8) outer limiting membrane; (9) layer of rods (long, narrow) and cones (short, thick); (10) pigment cell layer, attached to choroid. There are many thousands of rods and cones, covering the entire back inner surface of the eye; the diagram shows only a few. [Based on Piersol.]

A line joining the center of the pupil with the center of the retina passes through the center of the lens and through the center of the eyeball. The region about the center of the retina has a yellowish tinge and is called the *macula lutea* (yellow spot). It contains only cones — no rods. Near the center of the macula there is a depression in the retina called the *fovea centralis*. Here the cones are crowded together more closely than elsewhere. The result of this crowding is that we can discriminate fine lines and points most sharply at the fovea. It is the region of clearest vision. When we wish to examine any object closely we turn the eye so that the picture of this object falls on the fovea.

(2) BLIND SPOT: The optic nerve does not distribute its fibers on the outer surface of the eyeball in man and other vertebrates. The whole nerve passes in bodily, through the outer coating at the back of the eye, and distributes its fibers over the inner surface. In the place where the nerve breaks through the eyeball there are no rods or cones. This region is called the *blind spot;* it is somewhat circular but irregular in shape, and differs in different individuals. [Fig. 23.] You cannot see an object whose picture falls on this part of your eye. The blind spot lies some distance to the nasal side of the center in each eye, and slightly below the level of the center. If you look steadily at a small mark on a white surface with the right eye, the left being closed, a figure somewhat to the right of the fixation point will not be seen at all. [Fig. 24.] The blind spots of the right and left eyes are in different parts of the

FIG. 23. — MAP OF BLIND SPOT

Blind spot of the author's right eye. Drawn from two nearly identical records made a year apart. F = fixation-point.

retina, so that with both eyes open we do not notice any break in the field.

FIG. 24. — HOW TO FIND THE BLIND SPOT

Close the left eye. Hold the book about 5 inches off and look at the star fixedly with right eye. Move the book slowly to and from the eye till the right-hand spot disappears. Repeat with right eye closed and the left-hand spot will vanish.

(3) INTERMEDIATE FIELD: The region of the retina around the macula (except the blind spot) contains both rods and cones. The rods are more numerous than the cones and surround them.

(4) PERIPHERY: The outer rim of the retina, toward the front of the eyeball, is called the *periphery*. It contains no cones, only rods. In this region we see things rather indistinctly and cannot distinguish colors; all objects appear grayish, as in a photograph. This effect may be observed by closing one eye and bringing a small bit of colored paper slowly into the field of the other eye from behind your back, taking care to keep the eye fixed steadily straight ahead.

Eye Muscles. — Sight is assisted greatly by muscular adjustments. The *iris* and *accommodation* muscles inside the eyeball have already been described. The iris regulates the amount of light admitted to the eye, and the accommodation muscle focuses the picture clearly on the retina. There are also six muscles attached to the outer surface of the eyeball, which serve to move it about in the socket and keep it in position. [Fig. 25.] These are arranged in three pairs. One pair produce movements from side to side, horizontally; they are called the *internal rectus* and *external rectus* muscles. (The internal is on the nasal side.) A second pair cause the eyes to turn up and down; they are called the *superior rectus* and *inferior rectus* muscles. The third pair pass obliquely across the eyeball, one above and the other beneath it; they

are called the *superior oblique* and *inferior oblique* muscles. The oblique muscles assist in up and down movements; they

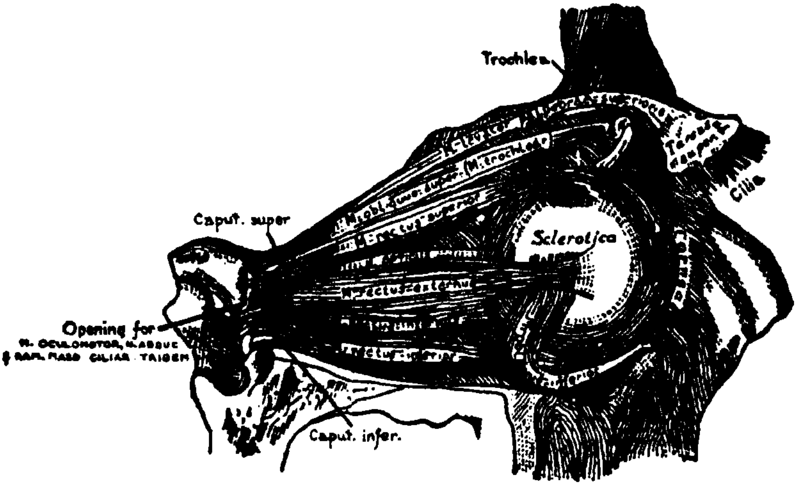


FIG. 25. — EYEBALL AND EYE MUSCLES

Right eye viewed from right side. The external rectus muscle is in central foreground, the internal rectus slightly below and behind it. The four other muscles are shown above and beneath the eyeball. Upper edge of optic nerve is seen just above external rectus. [From Smith and Elder.]

also hold the eyeball in place during its movements and prevent it from twisting circularly like the hands of a clock.

How the Eye Acts. — From every point of a lighted surface the rays of light spread out in all directions: but only those that strike the open pupil can pass into the eye and stimulate the retina. Take for example the point A, in front of the eye and above the center. [Fig. 26.] A bunch of rays from A pass through the cornea and aqueous, then through the pupil into the lens. On account of the curved shape of the lens, the rays are bent together before they pass into the vitreous, so that they come together at a point (or focus) on the retina at A'.[1] The rays from a point B, below A, focus on the

[1] If the lens is too rounded (near-sightedness) or too flat (far-sightedness) the rays do not focus on the retina, and the point is blurred. Eye-glasses are

retina at B', above A'. Points to the right of A focus to the left of A', etc. In other words, the picture of any object is completely inverted on the retina, like the image in a camera.

By means of the focusing process each point of the object before us stimulates a single rod or cone on the retina. The stimulation is some sort of chemical action. Each nerve fiber terminating in the retina is excited individually by a rod or cone, and the resulting impulses are conveyed to the visual center in the brain. [Fig. 27.] The separate fibers come together and form the optic nerve, which passes out of the eyeball through the blind spot. The optic nerves from the right and left eyes come together at the *optic chiasm,* where the nerve fibers from the nasal half of each eye cross over, while those from the outer half continue along on the same side. Consequently the center for the right half of each retina is in the right side of the brain, and that for the left in the left side.

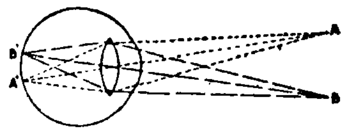


FIG. 26. — FOCUSING OBJECTS ON THE RETINA

Rays from A (dotted lines) spread in all directions, but are bent in by the lens and meet at A′ on retina. Rays from B (broken lines) are focused at B′. Rays from points between A and B focus in the same way, giving a clear but inverted image on the retina.

In order to see an object clearly, the picture on the retina must be focused accurately. This focusing is not done (as in a camera) by moving the sensitive plate back and forth, but by changing the curve of the lens. When we look at objects near by, the accommodation muscle squeezes the rim of the lens and makes it more rounded; when we look at things farther off the muscle relaxes and the lens becomes flatter.[1] The change takes place automatically.

used to correct these two faults — concave lenses for near-sight, convex for far-sight.

[1] In astigmatism the accommodation muscles contract irregularly, so that the lens does not focus for both axes at once. This is corrected by eyeglasses which are more curved in the horizontal direction than in the vertical, or vice versa.

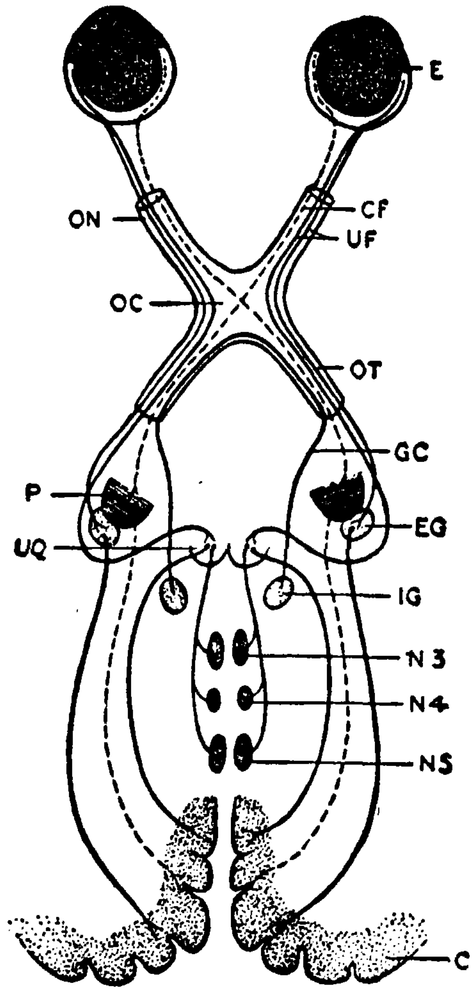


FIG. 27. — COURSE OF THE OPTIC NERVE

The optic nerves (ON) from the two eyeballs (E) run back into the head and meet at the optic chiasm (OC). Fibers from the nasal half of each retina cross (broken lines CF); those from the outer half (unbroken lines UF) curve out again and proceed on same side of head through the optic tract (OT) to visual centers in the brain. The lower visual center is in parts of the thalamus called the pulvinar (P) and external geniculate body (EG). Center for touch sensations from eyeball is in the upper quadrigeminal body (UQ). From the thalamus, projection fibers proceed to the higher visual center in the occipital lobe of the cortex (C).

N3, N4, N5, = nuclei of III, IV, V cranial nerves, for eye movement; GC = commissure of Gudden, connecting the lower visual centers on the two sides of the brain. [Modified after Lickley.]

The iris muscle also works automatically. Bright light causes the iris to contract, so that the pupil becomes smaller. The dazzling effect of a sudden glare of light is due to the fact that the iris has not had time to contract sufficiently.

The muscles for eye movement work both automatically and voluntarily. An inherited system of nerve connections controls their operation; when the rays from a bright or noticeable object fall on any part of the retina except the center, the appropriate eye muscles are contracted so as to turn the center of the pupil directly toward this object. This is called *involuntary fixation.* We also turn the eyes voluntarily, by contracting one of the four rectus muscles, or by contracting one of the horizontal pair and one of the vertical pair at the same time.[1] Eye movement, whether voluntary or involuntary, helps us to see more clearly, since the center of the retina is the region of sharpest discrimination. We see an object best when we fixate it on the fovea; if the object is in motion, we follow its course with the eye, keeping it on the fovea.

Stimuli for Sight. — The light rays which stimulate the eye are not material particles, but waves in the ether. They are exceedingly minute and travel very rapidly. The largest visible light waves are only 760 millionths of a millimeter ($\mu\mu$)[2] in length; the smallest waves that affect the eye are about 390 $\mu\mu$. All light waves, whatever their length, travel through the atmosphere at the same speed — about 300,000 kilometers or 200,000 miles per second. This means that a greater number of short waves reach any given point every second. In other words, short waves have a relatively large number of vibrations, long waves a relatively small number of vibrations per second. [Fig. 28.]

When sunlight, which contains waves of all lengths, is

[1] There is always some adjustment of all the other muscles when the eye moves.

[2] Pronounced mew-mew.

passed through a prism its direction is changed. This bending is called *refraction*. The short waves, because they are short, are deflected from their course more than the long, so that the different waves spread out like a fan. [Fig. 29.] If

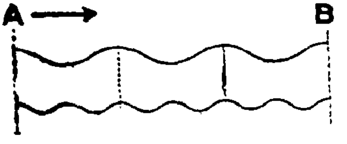


FIG. 28. — LONG AND SHORT LIGHT WAVES

The upper wave is *twice as long* as the lower. Since they travel at the same speed from A to B, only *half as many* of the long waves will reach B in a given period of time. The longer the wave length, the fewer waves per second.

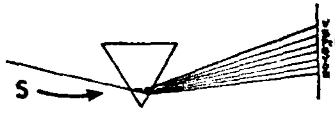


FIG. 29. — REFRACTION OF LIGHT

A ray of sunlight, containing waves of all lengths, coming from S passes through the prism and is refracted. The shortest waves (violet end of color series, V) are bent most, longest waves (red end, R) least. They spread out on a reflecting surface and form a spectrum of colors.

refracted light is thrown on a white surface each wave length gives a different color; the entire series of colors obtained by refraction is called the *spectrum*.[1] Each distinguishable color is caused by a certain definite *wave-length* of light, — or by a certain uniform *number* of light waves striking the eye every second; we can express it either way.

In addition to their differences in wave-length, light waves vary in *intensity*. Bright light is caused by more violent vibrations — the waves swing farther from side to side as they move along. Intense (or bright) light acts more powerfully upon the rods and cones of the retina and produces a sensation of greater intensity when the resulting nerve impulse reaches the visual center.

Qualities of Visual Sensations. — In studying each of the senses one of the first questions is, What are the different sorts of impressions that it gives us? So in examining the sense of sight we have to determine the various qualities of visual sensations. First of all, we find two distinct groups of sensations, *colors* and *grays*.

[1] The spectrum is seen in the rainbow.

Pure *color* sensations, or *hues*, are produced by stimuli which consist of uniform light waves. If the waves that strike the retina are about 400 $\mu\mu$ in length we see violet; if they are 650 or more we see red. The series of colors lies between the limits 390 and 760 $\mu\mu$.

Gray sensations are produced by stimuli of mixed light waves in which no single wave predominates. The pure gray sensations form a series of their own, the extremes of which are called *white* and *black*.

In addition to these two pure groups there is a third class of impure sensations, which combine in various ways the color effect with the gray effect. They are produced by a mixture of color stimuli with gray stimuli. Most of our visual sensations are of this sort.

The relations of visual sensations to one another may be studied by means of colored disks which are fitted together and placed on a color mixer. [Fig. 30.] When we spin the

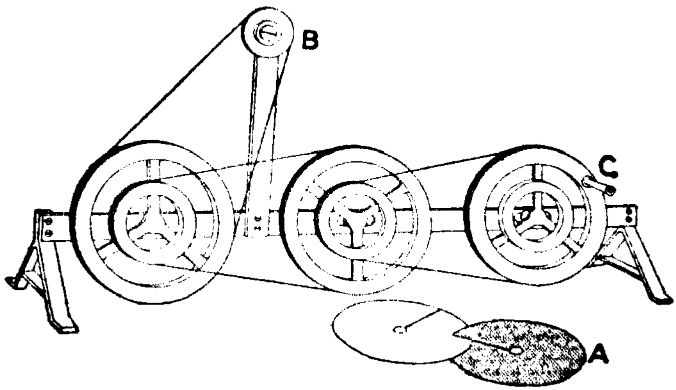


FIG. 30. — COLOR MIXER

The colored disks (A) are slit from circumference to center so they can be fitted together, with a segment of each disk showing. The disks are fitted around a projection to the axis of B and screwed fast. The mixer is rotated by turning a handle C. By the series of belts connecting the three wheels with B the speed of rotation is greatly increased.

interlocked disks around very rapidly, the colors (or grays) blend together and give an intermediate sensation. If we

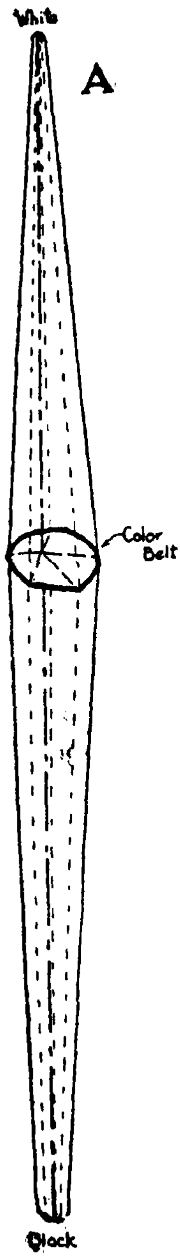
start with a pure red disk and little by little add a segment of yellow, we can determine just how much yellow must be added to red in order to produce a noticeable change in sensation. And so for the changes from yellow to green, etc. In the same way we can observe the just noticeable changes in a gray series by mixing a white disk with a segment of black or vice versa. The impure sensations are obtained by combining each of the pure color disks with a black or a white or a gray disk on the mixer.

When we have made all possible combinations of colors and grays on the color mixer we shall have found all the different qualities of visual sensations. The relations of these sensations to one another may be shown by a diagram which takes the form of a spindle.[1] [Fig. 31 A. The central cross-section, with the belt of pure colors, is enlarged in Fig. 31 B.] Bear in mind that the spindle-shaped figure represents only the *relations* of the colors and grays as seen by the eye — not the relations of the physical light waves which stimulate the retina. The various visual sensations are represented on the spindle as follows:

(1) Hue or Color Tone: The relations of the pure colors are represented in the form of an irregular belt, shown in Fig. 31 B. The sectors in this diagram mark off the more prominent hues — red, orange, yellow, olive, green, peacock (or blue-green), blue, and violet. Each of these names really applies to a number of distinguishable hues; for instance, even in the pure colors seen in the spectrum we can distinguish several sorts of red, which look more and more like orange; then several sorts of orange which look more and more like yellow, and so on to the extreme violet.

There are also a number of hues which are not produced by single light waves, but are due to mixing red and violet light in various proportions. These hues make up the *purple* sector of the belt. They are just as real hues and just as simple

[1] It is also called a *color cone* or *color pyramid*.



sensations as any others, though they are not due to simple waves. This explains why we represent the hues by a continuous belt instead of by a line. If we start with red and keep changing the hue we pass through all the spectral colors to violet, and then through purple to the red we started with. All told there are about 160 distinguishable pure colors, including the purple hues.

(2) SHADE OR BRIGHTNESS: The pure gray sensations are represented by the central axis in Fig. 31 A. One end of the

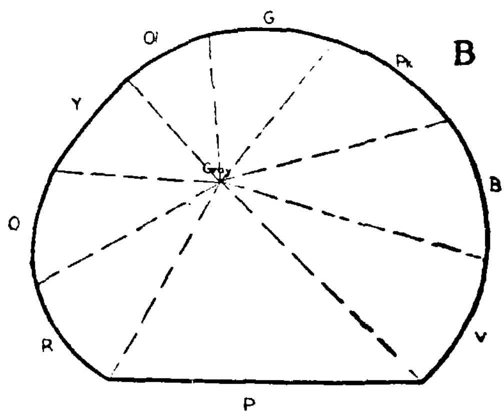


FIG. 31. — COLOR SPINDLE AND COLOR BELT

A. Color spindle; showing schematically the various distinguishable visual sensations, arranged according to shade (vertical direction), tint (radii from central axis), and hue (angles about axis). The gray series is represented by the central vertical axis. The purest hues (most saturated color tones) lie on the circumference of the color belt. The relative proportion of shades, tints, and hues is indicated by the relative number of units assigned to each. (Notice the great preponderance of shade-units over others.)

B. Color belt, enlarged; showing relative number of distinguishable hues of each spectral color and of purple; relative saturation of the various pure hues is indicated by distances of the belt from central gray axis. Colors represented by the sectors: Red, Orange, Yellow, Olive, Green, Peacock (= blue-green), Blue, Violet, Purple.

axis represents the whitest white, the other end represents the blackest black. There are about 700 distinguishable *gray shades*[1] between these two extremes.

A color may be made brighter or darker by mixing it with white or black. If we take a red disk, for instance, and interlock it with a white disk, the mixture is bright red. If we put a red disk and a black disk together, the mixture is a dark red. These are different *color-shades.* The color-shades are represented on the spindle by vertical lines parallel to the gray axis.

Figure 32 A shows how a series of red color-shades may be obtained on a single disk. Such a series may be found for each distinguishable color hue. A color-shade may be compared with a gray-shade by interlocking a disk of each and rotating them slowly on the color mixer. If one is brighter than the

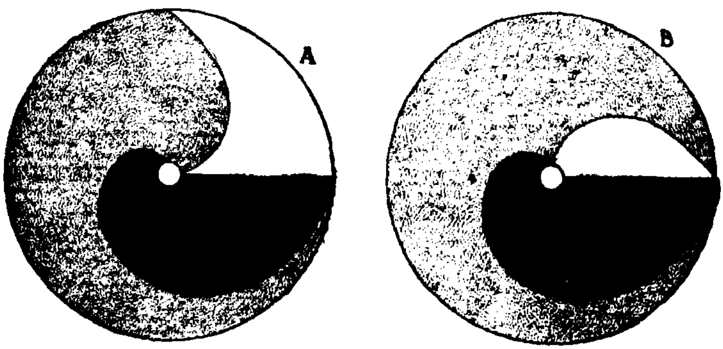


FIG. 32. — SERIES OF COLOR-SHADES AND TINTS

A. Color-shade series. — The mottled surface represents red. If disk A be rotated on a color-mixer, we get a series grading from bright red at the circumference to dark red at the center; same amount of color (saturation) everywhere.

B. Tint or saturation series. — Mottled surface represents red. If disk B be rotated, we get a series of tints grading from pure, saturated red at the circumference to pale, unsaturated red ending in colorless gray at the center; same amount of brightness (shade) everywhere.

other they will flicker; if they are of the same shade there is no flicker at all.

(3) TINT OR SATURATION: There is still a third way of varying the quality of visual sensations, namely, by mixing

[1] Artists use the term *value* instead of shade or brightness.

together a pure color and a gray in various proportions. If the color and the gray are of the same brightness, these mixtures will all be of the same shade; yet they will be quite different. If the mottled portion of the disk in Fig. 32 B is reproduced in red, when the disk is rotated on a color mixer we observe a pure red at the circumference; passing toward the center we observe a graded series in which the color becomes less and less pronounced; the center is a pure, colorless gray. This change, which is neither a change of hue nor a change of shade, is called *saturation*, or chroma, or tint. A pure color is said to be 'completely saturated'; its saturation decreases as more and more gray is added to the mixture. Gray is 'completely unsaturated.' The partly saturated colors observed by rotating Fig. 32 B form a series of *tints*.[1]

The differences of tint are represented in our spindle diagram by radii from the axis toward the circumference. The farther from the axis, the greater the saturation. It will be noticed that some of the radii are shorter than others. This means that some pure colors in the spectrum are found to be less saturated than others. Yellow, for instance, is decidedly less saturated than violet; there are more steps of difference in passing from violet to gray of the same shade, than in passing from yellow to gray. When any two hues are mixed the resulting color is less saturated than either of them taken separately. Consequently the purple hues, which are obtained only from mixtures, are represented on the belt by a straight line. All purples are relatively unsaturated; they have fewer tints than the spectral colors.

Every visual sensation has a certain assignable position on the spindle figure. Every color has a certain hue, shade, and tint. Gray has only shade; we might say that its saturation is zero. Our diagram also brings out the fact that very bright

[1] *A vivid tint* means that the color is very pure or saturated. A *pale tint* means that the object is mainly gray, with very little color; it may be either dark or bright — that is a question of shade.

and very dark colors are quite unsaturated; near the white and black poles there are relatively few steps between pure color and gray. It is estimated that, all told, about 30,000 visual qualities can be distinguished by the normal human eye.

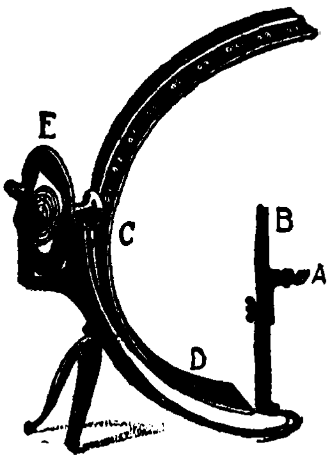


FIG. 33. — PERIMETER

Observer's chin is placed on a rounded chin-rest at A, which is so adjusted that one eye is directly over semicircular top of rod B, the other eye being closed. A small hole through the axis at C serves as fixation point. Color stimulus is moved on a carriage along the semicircular arm, D, of perimeter toward or away from center. On the back of the arm is a scale of degrees. The arm D rotates, so that all parts of the visual field can be explored. On outer side of plate E (which rotates with D) is fastened a chart, ruled radially and circularly to represent degrees of 'latitude' and 'longitude' from center of vision. Experimenter records the readings on the chart, which is hidden from observer by E. [From Judd, after Meyrowitz.]

Primary Colors. — Artists and physicists, as well as psychologists, are interested in the question of what colors are primary. Newton's list of seven colors is familiar to every one; but it has no special significance. Newton was misled by the analogy of the musical scale and thought there must be seven tones in the color scale also. It has long been known that by taking three hues — red, green, and blue — and combining them together on a color mixer in various ways any hue can be obtained. This has led to the idea, which still prevails popularly, that these three hues are primary or *fundamental* colors. In a way this is true. But on the other hand psychologists find that yellow is quite as distinctive a color as the three just mentioned. It is also a fact that orange, violet, and indeed every separate hue in the spectrum, is a simple color — the result of a simple stimulus. Are there three primary colors, or four, or a hundred?

A curious fact suggests the answer to this question. If the eye be fixed on a point straight ahead, and a small bit of

colored paper be moved slowly from the fixation-point out toward the periphery, it is found that most colors change noticeably in hue as they get farther from the center. A red becomes yellowish, and so on. But there are four definite hues which do not alter in this respect.[1] These four 'invariable' hues are called *primal colors,* and may be regarded as the most primitive and representative hues of all; they are a certain definite blue, green, yellow, and red. Curiously enough, primal red is not a spectral hue. It is slightly purplish. The primal colors and the changes which occur in other hues near the periphery may be observed by means of the *perimeter.* [Fig. 33.] Table II shows the wave-lengths of the primal colors and the wave-lengths of the groups of hues to which popular names are given.

TABLE II.— SPECTRAL LINES AND COLOR RANGE

Spectral Line	*Wave-Length* $\mu\mu$	*No. of Vibrations* Trillion per second	*Color Hue*	*Range* $\mu\mu$
A	766.1	391.41		
Primal Red	——	——		
B	687.0	417.06	Red	760–647
C	656.28	456.91		
D_2	589.0	509.01	Orange	647–588
Primal Yellow	577	521	Yellow	588–550
E	526.96	569.03	Green	550–492
Primal Green	501	599		
F	486.14	616.82	Blue	492–455
Primal Blue	477	629		
G_1	432.58	693.19	Violet	455–390
H	396.84	755.62		

Visible Range: 760–390 $\mu\mu$, 399.55–768.87 trillion.

Limits of Color Change: 655–430 $\mu\mu$.

(Wave-lengths from Houstoun, *Treatise on Light,* p. 473. Primal colors from Titchener, *Exper. Psychol.,* Vol. I, Part I, p. 4.)

Purkinje Phenomenon and Adaptation. — Most of our color sensations are due to the reflection of light from painted surfaces. The paint pigments absorb all rays except one

[1] At the periphery they become gray, as do all colors; but the *hue* does not vary — it only fades out.

wave-length; the reflected light is of the hue corresponding to the non-absorbed wave-length.

The brightness of pigment colors varies with the intensity of the general illumination. In a darkened room all colors appear darker; but the brightness of different colors changes at different rates. When the general illumination is very bright, yellow and red become relatively brighter than other colors. If the room be made very dark they appear darker than blue or green. This is especially noticeable if we compare red with blue. A red book-cover which appears much brighter than a blue cover in a well-lighted room, will appear darker when the light is turned very low. This peculiar variation in the relative brightness of colors is called the *Purkinje phenomenon*, from the man who first reported it.

The Purkinje phenomenon is part of the process of adaptation to intense and feeble illumination which takes place in the retina itself, due to changes in the condition of the rods and cones. When we go suddenly from darkness to bright daylight the eyes are dazzled. After a time the eyes become adapted to brightness. In the same way the eyes adapt themselves to a darkened room. The process of adaptation is greatly assisted by the iris reflex.

There is also adaptation when the general field of vision is tinged with some color. If we put on green glasses the whole landscape at first appears green. After a time this tinge disappears, and our outlook is apparently normal, except that red objects appear gray.

Complementaries, After-sensations, and Contrast. — If a disk of yellow cardboard and a disk of blue be fitted together so as to give a surface half yellow and half blue, and this be rotated rapidly on a color mixer, the two will tend to neutralize each other. If we select a certain hue of each and mix them in various proportions, at some point we get a mixture in which *no color effect whatever* is observed: the disk appears as a plain gray surface. For a given yellow, a certain blue

can be found which yields this effect. This yellow and this blue are called *complementaries* or *complements.*[1] For every color hue in the series, including the purples, one and only one complementary hue exists.

If we look steadily for about a minute at a very bright colored object (a red blotter, for instance) and then turn the eye quickly to a white wall, we see on the wall a patch of the complementary color (bluish green, in this case). This after-effect is called a *negative after-sensation.*[2] It is due to fatigue of the portion of the retina stimulated by the bright color. White gives rise to a black after-sensation, and conversely. For this reason white and black are regarded as complements.

After practice one can get an after-sensation more readily and hold it longer. If you reach this stage you will observe another effect also; after the eye is turned toward the white wall there appears first of all a sensation of the *same* color as the object you were looking at. This is a *positive after-sensation.* It lasts only a very short time and then changes into the negative. The positive after-sensation is due to inertia of the retina.

Often a strong negative after-sensation after persisting some time changes into a second positive, and this again into a second negative. These effects are obtained only after great practice and under very favorable conditions; all except the first positive are due to fatigue and recuperation of the retina.

Complementary effects may be brought about under certain conditions without moving the eye. If we place on a color mixer a disk containing a ring which is partly black and partly white, surrounded by a uniform color (e.g., blue), when the disk rotates the black and white ring it not seen as gray, but is tinged with the complement (yellow) of the surrounding color. [Fig. 34.] A similar effect is obtained by placing a

[1] The latter is a term recently suggested by Christine Ladd-Franklin.
[2] It is also called an *after-image.*

bit of gray paper on a colored blotter and covering the whole with white tissue paper. The appearance of a complementary effect *without eye movement* is called *simultaneous contrast.* The complementary color which appears around the borders of a colored figure on a white background when the eyes wander is a negative after-sensation. It is called *successive contrast.*

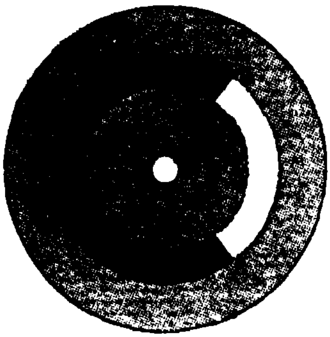


FIG. 34. — CONTRAST COLOR

Mottled surface represents blue. Rotating the disk, the black and white ring is tinged with yellow; if instead of blue the mottled surface is red, the ring takes on a greenish tinge.

Color Blindness. — A considerable proportion of persons show striking peculiarities of color sensation. They fail to distinguish between certain hues which lie far apart in the spectrum, such as red and green. This defect is called *color blindness.* Ask a color-blind person to hand you the red book on the table and he is just as likely to hand you a green book. You think he is joking; but really he is acting in perfectly good faith; — he cannot tell the difference between red and green. Color blindness is due to something in the make-up of the retina. Just what this is no one has yet been able to discover. It is not a diseased condition of the eye; for certain types of color blindness are inherited, like the color of the hair or shape of the fingers. It seems rather to be the survival of a primitive, less developed type of eye which may have been universal in mankind before color vision became perfected.

The most common form of color blindness is inherited in a peculiar way. It is found chiefly in males. The sons of such a color-blind person do not inherit the peculiarity, and his daughters inherit only the latent possibility. They are not color blind themselves, but their sons are color blind. In other words, this form of color blindness is transmitted from

a man to his daughter's sons. There are also forms of color blindness which appear in women as well as men.

Color blindness is either *total* or *partial*. A totally color-blind person sees everything like a photograph; the world appears to him in black and white and shades of gray, without any color whatever. This form is quite rare.

There are three distinct varieties of partial color blindness, which are popularly called red, green, and blue blindness. Blue blindness is rare and is possibly due to some diseased condition of the retina. In this form the person is unable to distinguish between blue and yellow.

Red and green blindness are the most common forms. In each there is confusion between red and green. But the two forms are distinct. This is demonstrated if we ask the person to tell us how the spectrum looks to him. A red-blind individual sees nothing at all at the red end of the spectrum. The green-blind person sees something throughout the spectrum, but he confuses red and green with yellow.

How do we know just *what* the colors look like to a partially color-blind man? Our description would seem to be mere guesswork. But, as it happens, cases have been found in which one eye is color blind and the other eye normal. Such persons are able to compare the sensations of their two eyes and to translate the abnormal eye into terms of the normal.

Color blindness raises certain very practical issues. On the railroads and at sea the two colors red and green are commonly used as signals. It is sometimes a matter of life and death to distinguish them clearly and immediately. A color-blind engineer may make a fatal mistake. Many tests have been devised to determine color blindness. Some of these are open to serious objection. Color-blind persons can distinguish differences of shade very accurately. If only a few standard cards are used in the test, one may learn to distinguish these particular cards by their shade and so pass the test.

A test devised by Stilling meets this objection. It consists of a set of cards with a great many round colored spots of various sizes and shades scattered about promiscuously. Most of the spots on each card are of one color (say, red), with a few of the other color (green) interspersed. The green spots are arranged in the form of numerals, so that a normal person will see immediately and clearly the number 37 (or whatever it is) in the pattern. A color-blind person looking at the card can see only the differences of shade: he cannot pick out the number, but will trace some entirely different pattern. It is practically impossible to fool this test.

Color Zones. — At the periphery of the eye color qualities disappear even in normal persons. We are all color blind in this region. Unless the stimuli are exceptionally bright everything looks gray, like a photograph, at about 90 degrees in any direction from the point on which the eye is fixed. Some colors disappear before others. Green, for instance, is limited to a much smaller region than blue or red. The region in which we can see any color is called the *zone* for that color. These color zones are determined by means of the perimeter.[1] A map of the color zones in a typical eye is shown in Fig. 35.

Visual Intensity. — In sight, changes in intensity or brightness are closely related to the gray series of qualities. White is always very intense: black is of faint intensity. The Purkinje phenomenon and adaptation may be treated as intensity relations.

Experimental psychology is interested in two problems of visual intensity: (1) What stimulus produces the *least observable* visual intensity, or brightness? (2) What change of stimulus gives rise to the *least observable change* in brightness? These same questions crop up in every one of the senses. The least observable *changes* in sensations will be treated together after we have finished our study of the separate senses.[2]

[1] See Fig. 33, p. 74. [2] See p. 146–149.

The least observable visual brightness may be determined as follows: The observer is placed in a darkroom with black-

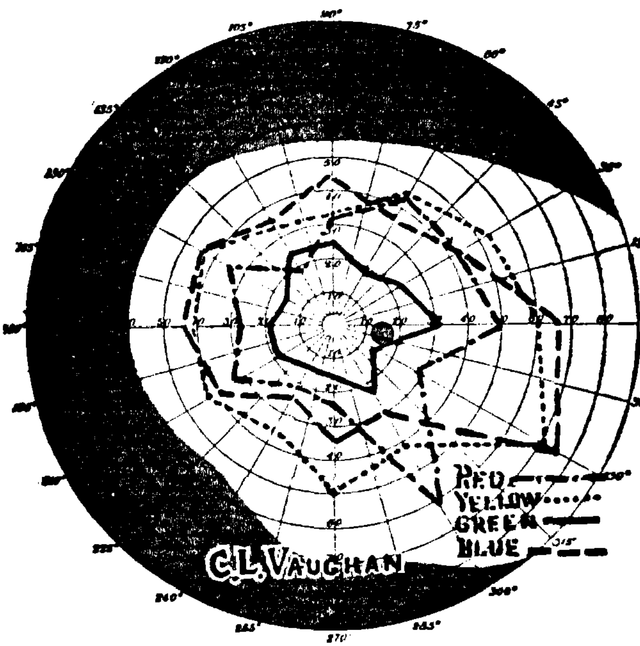


FIG. 35. — COLOR ZONES OF THE RETINA

Limits at which four colors disappear in passing from center of eye toward periphery, determined for radii 30 degrees apart. Right eye.

ened walls. On a dull black surface before him a pencil is fixed upright. A light of standard brightness is moved slowly toward the pencil from a distance, till the subject just barely observes the shadow cast by the pencil. The faint light bordering on the shadow is called the *least observable brightness.* Certain visual processes occur in the retina, however, even when no stimulus is present; we often see dust clouds or spots of light when our eyes are closed in the dark. So that this experiment really measures the brightness of the objective stimulation which is just observably different from the eye's own retinal light. According to Langley the energy of

the light which produces the least observable visual sensation under most favorable conditions is 0.000,000,03 ergs.

Explanation of Visual Qualities. — Many facts in the sense of sight are peculiar and difficult to explain: Why do the two extremes of the spectrum, red and violet, look somewhat alike? How is it that purple, a simple color, is not found in the spectrum? Why is yellow a distinctive color, though it is not among the three that are sufficient to produce every hue by mixture? How can we account for the various sorts of color blindness, and the wide prevalence of color blindness in the human race? Why is the periphery of the retina color blind even in the normal eye?

Most puzzling of all is the sensation of *black*. Black is as much a sensation as white or any of the color hues; yet it is not due to stimulation by light waves at all. It is aroused when *no* light stimulates that particular portion of the retina, though to get a distinct black sensation some nearby region must be stimulated by light.

These extraordinary facts indicate beyond question that the processes in the retina are very complicated. Even to-day they are not understood. The explanations suggested are only partly satisfactory; they do not cover all the facts.

The genetic theory of sight, which was devised by Christine Ladd-Franklin, seems to fit the facts best. This explanation starts with the notion that color vision has evolved gradually from a more primitive type of eye which could see only shades of gray. It supposes that there exists in the rods and cones a certain substance, which when stimulated by light arouses sensations of gray and white. This substance occurs in the retina in the form of particles called *color molecules*. In the primitive eye only gray and white were distinguished.

In the course of evolution the color molecules in the cones became differentiated into two components,[1] one of which

[1] The color molecules in the rods are not differentiated: they give gray only.

when stimulated yields sensations of blue, while the other yields sensations of yellow. Later on in history the *yellow* component became differentiated in turn into two components, one yielding red, the other green. So in the fully developed eye there are four primal colors: red, yellow, green, and blue. But since red and green are derived from yellow, yellow is not essential to color combinations like the other three. This theory explains why red and green color blindness are comparatively common, and why the normal eye does not distinguish colors peripherally: in color-blind persons the color molecules are only partly developed; and the periphery is capable of giving only sensations of gray because this region has no cones.

The Ladd-Franklin theory seems to cover all the perplexing phenomena of sight except the sensation of black. The best plan is to accept this view as a partial explanation, recognizing that it does not tell the whole truth.[1]

One conclusion is forced upon us more and more as we study the sense of sight: this sense has by a long process of evolution developed an exceedingly complicated organ, which has come to fit our needs most admirably. It furnishes us with a vast number of elementary sensations which give an incalculable variety to our experiences. We can see very fine distinctions of color and shade. We can distinguish very fine lines and points. We can observe objects at a very great distance from our body by means of sight. Of all the senses, sight has the greatest practical importance in human life.

PRACTICAL EXERCISES:

16. Describe the after-sensations of color obtained by looking across the room at a window-sash on a bright day, and then closing the eyes, or turning them to a dull gray surface.
17. Describe your experience of visual adaptation on going suddenly from a very light to a very dark room and *vice versa*. Note especially the Purkinje phenomenon (p. 76).

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[1] There are two other important color theories, one devised by Young and Helmholtz, the other by Hering.

18. Test the limits of your color zones for red, yellow, green, and blue. This requires assistance. The test should be made in a room with white walls. Cut out small bits of each color and place one at a time on a black or white strip of cardboard. The assistant brings the color gradually in from right or left till the color is recognized. Test one eye at a time, with the other eye bandaged.
19. Make a map of some one's blind spot. Bandage one eye and fix his head by a head-rest fifteen inches from the wall. Place a sheet of white paper on the wall, marking a cross in the middle for fixation point. Make a pointer of white cardboard, with the tip (one-eighth inch square) blackened, and move it slowly across the paper. Mark in pencil each spot where the black tip disappears or reappears.
20. Examine various colored objects in your room, including surface of walls, tables, chairs, and floor. Describe their shade in five grades: very bright, bright, medium shade, dark, very dark. Describe their tint (saturation) in three grades: very pure color, medium saturation (much gray), slight tinge of color (very pale).
21. With eyes closed place the blocks in the form-board (p. 175). Notice the length of time required and the errors made. Repeat with eyes open, and compare the two performances.

[Exercise 20 is on visual qualities; 21 is on the relative importance of sight and touch; the other exercises are self-explanatory.]

References:

On the eye: Ladd and Woodworth, *Physiological Psychology*, pp. 182–196.

On visual sensations, color blindness, etc.: J. H. Parsons, *Introduction to the Study of Color Vision;* E. A. Schaefer, *Text-book of Physiology*, article on 'Vision'; M. Greenwood, *Physiology of the Special Senses;* chs. 10–20.

On visual theories: C. Ladd-Franklin, in *Mind*, N.S. 1893, **2**, 473–489; Parsons, *op. cit.;* Greenwood, *op. cit.*

CHAPTER V

THE SENSES: HEARING AND OTHER SENSES

2. HEARING (AUDITION)

The Ear. — The human ear is a very complicated organ. The peculiar-shaped shell to which the name *ear* is popularly applied is only an insignificant part of the apparatus for hearing. It merely collects the stimuli and directs them into the proper channel. The real ear lies inside the head.

The receptor for hearing is divided into the outer ear, middle ear, and inner ear. [Fig. 36.] The outer ear consists

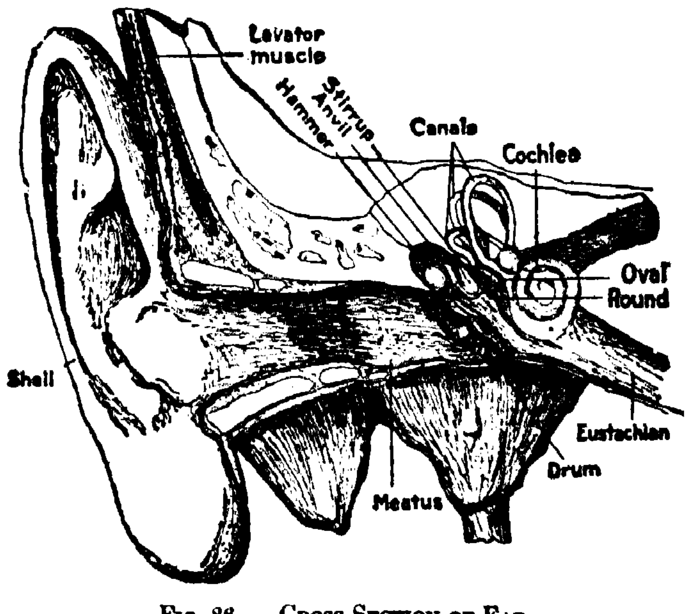

FIG. 36. — CROSS-SECTION OF EAR

Vertical section of right ear through meatus and Eustachian tube, viewed from front of head.

of the *shell* (concha), together with a tube, about an inch long, called the *meatus*, which leads into the head through an open-

ing in the skull and ends in a vibrating membrane called the *ear-drum* (tympanic membrane).

The middle ear lies beyond the drum. It is a small cavity in the head, containing three small bones which take up and transmit the vibrations from the drum. The middle-ear cavity is the end of a passage (the *Eustachian tube*) which opens into the back of the mouth. If the drum is pressed back too far into the middle-ear cavity by a tremendous sound, we may remedy the trouble by swallowing, which forces air into the Eustachian tube and pushes the drum forward into place. In the bony wall of the middle-ear cavity, opposite the drum, are two apertures, called the *oval window* and *round window*. They are not open; but each is fitted with a vibrating membrane, which permits the sound waves to pass through, just as the glass in a window-pane admits light waves.

The three small bones of the middle ear form a chain. The *hammer* bone (so called because it is shaped like a rude, primitive hammer) is attached to the center of the drum at the handle end, and at the middle is held in place by a tendon. The head of the hammer fits into the second bone, called the *anvil;* and the anvil attaches to the arch of the *stirrup* bone, whose base is attached to the membrane of the oval window.

The sound waves gathered by the shell of the ear pass through the meatus and set the drum in vibration. This vibration affects the handle of the hammer; the hammer being pivoted in the center, its head beats on the anvil, which jars the stirrup, and this sets the membrane of the oval window vibrating in exact measure with the original sound waves. But this is not all. The crucial process of hearing takes place in the inner ear.

The inner ear or *labyrinth* is a very complicated cavity, only part of which is concerned with hearing. [Fig. 37.] The portion toward the back of the head contains the semicircular

canals, which are receptors for the static sense;[1] they have nothing to do with hearing. The front part of the labyrinth contains a spiral structure resembling the shell of a snail, called the *cochlea*, which contains the real receptor for hearing. Between the canals and the cochlea is a cavity called the *vestibule*.

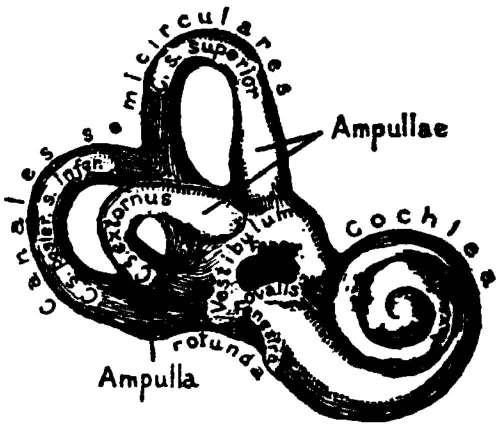

FIG. 37. — LABYRINTH OF THE EAR

Enlarged view of labyrinth in nearly the same plane as Fig. 36. Semicircular canals at left, cochlea at right; between them the two windows and vestibule. [From Smith and Elder.]

The inside of the cochlea is divided into two spiral tubes, lying side by side, which run from the base to the tip of the cochlea. [Fig. 38.] They are separated by a membrane, except at the top, where they unite. Between these two tubes (called the *scala tympani* and *scala vestibuli*) is a smaller tube called the *cochlear duct*, which is separated from them by membranes. In a small canal within the cochlear duct is a system of minute rods and hair cells, called the *organ of Corti*. [Fig. 39.] These rods and hair cells connect with the fibers of the auditory nerve, and are the real receptors for hearing.

We traced the course of the stimulus through the chain of bones as far as the oval window. The vibrations of the membrane in this window set up waves in the liquid that fills the cochlea. These waves pass up the scala vestibuli, which starts at the oval window; at the apex of the cochlea they go over into the scala tympani and pass down, finally reaching the round window at the base. (The round window serves

[1] See p. 117.

merely as a shock-absorber.) During the passage of the waves through the cochlea the cells of Corti are set into sympathetic vibration. They are of different lengths, and each picks up certain waves of corresponding length, just as the strings of a piano reverberate to sounds of their own length. When a wave of a given length passes through the cochlea, it sets in vibration the appropriate rod or hair cell of Corti, and this stimulates a certain fiber of the auditory nerve, which carries a nerve impulse up to the auditory center in the brain.

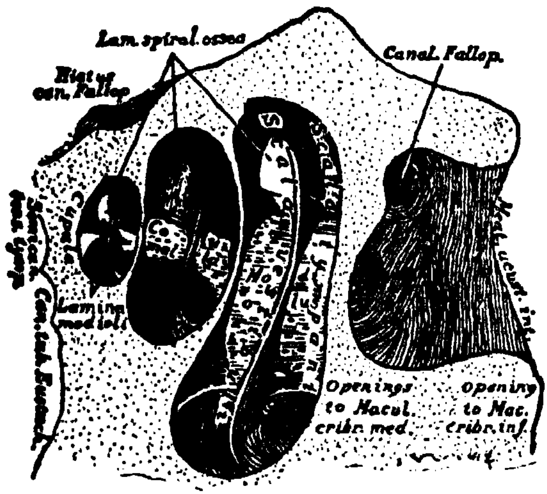

FIG. 38. — SECTION THROUGH COCHLEA

The cochlea cut open from apex to base near the central core (modiolus) at right angles to plane of Figs. 36 and 37. The apex or tip of cochlea is at left of the drawing. Section shows three windings of scala tympani (right) and scala vestibuli (left). The cochlear duct (not shown) lies between the two scalæ away from the core; it is bounded by two membranes which form a continuation of the spiral lamina (Lam. spiral. ossea). [From Smith and Elder.]

There is no muscular apparatus for focusing sounds in the human ear, such as we have in the eye. A rudimentary muscle exists for lifting the ear, but it is rarely used and in most persons is not under control of the will. We can focus sounds slightly by turning the head so as to make the effect clearer and more distinct.

Stimuli for Hearing. — The stimuli for hearing consist of vibrations called *sound waves*. These waves are very much more sizable than light waves and differ from them in many other respects. Sound waves travel through the air at the

uniform rate of 332.4 meters (about 1000 feet) a second. Like light waves they differ from one another in *length*. The longer the sound wave, the fewer waves strike the ear-drum

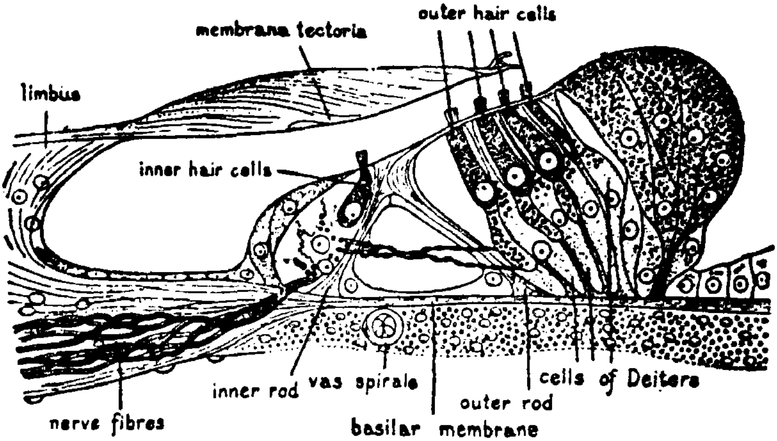

FIG. 39. — ORGAN OF CORTI

Section perpendicular to direction of windings of the scalæ. Rods of Corti are designated 'inner rod,' 'outer rod.' The rods and hair cells become longer in successive sections toward apex of cochlea. [From Lickley, after Retzius.]

in a given period of time. It is customary to measure sound waves in terms of the number per second instead of wave length.[1] The greatest frequency (rate of vibration) of sound waves that the average man can hear is about 30,000 per second; the lower limit is about 12 or 16. The rate of vibration determines the quality of sensation.

Sound waves may be started in three different ways: (1) by twanging a tightly stretched violin string, which being elastic vibrates to and fro; or by tapping a tuning fork or the membrane of a drum. (2) They may be started by blowing into a tube, which sets the air into vibration at different rates according to the length of the tube. (3) A third way of

[1] Because the *number* of waves per second is the same for any given sound, whether the vibration is of air particles or strings; the wave *length* would vary with the density of the medium.

starting sound waves is by tapping a rigid body, such as a bell or xylophone; here the rate of the sound waves depends on the size and material of the body, not on its elasticity. In every case the sound waves are eventually communicated to the air and so to the ear-drum. The only exception is where a vibrating fork is pressed against our head; the sound waves are then transmitted directly through the bones of the skull to the drum.

Sound waves differ not only in frequency (vibration rate) but also in *intensity*. The same sound (e.g., middle C on the piano) may be faint or loud, depending on the force of the disturbance in the air. If you pluck a violin string vigorously, the air particles do not move any faster, nor vibrate more times per second, but they swing *more violently* back and forth with each vibration. This results in a *louder* sound — not in a different quality of tone.

Qualities of Auditory Sensation. — Just as in sight, there are different qualities of auditory sensation for the various rates of vibration, and there are also sensations due to mixed rates. A uniform sound vibration gives a *tone* sensation; mixed vibrations give a *noise*.

The parallel between sight and hearing is not complete. A noise is not pleasant like gray light; and noises do not form an independent series like the grays — every noise is more or less like some tone whose vibration rate predominates in the mixture. Strike a table in different places and you will notice that the resulting noises are somewhat like dull, flat tones.

Tones and Pitch. — If we snap a tuning fork, the prongs vibrate to and fro uniformly, at a rate which depends on the length of the fork. This vibration causes uniform sound waves in the air, and the resulting sensation is not a noise but a *tone*. A long fork vibrates at a slow rate — that is, few times per second; it gives a deep tone. A shorter fork vibrates at a more rapid rate and the resulting tone is more

shrill.[1] The vibration rates between 12 and 30,000 give a series of about 11,000 distinguishable tones. The difference in quality between tones is called difference in *pitch,* and the whole series of audible tones is called the auditory *scale.* Tones and pitch correspond to colors and hue in the sense of sight. We ask, " What is the pitch of that tone? " just as we ask, " What is the hue of that color? "

The relations of tones to one another is quite different from the relations of colors. In the first place tones have not so much individuality. Take the tone produced by 256 vibrations, which is called middle C on the piano and is used as a standard.[2] Most persons are quite unable to identify it. If you ask a man to hum C, he is likely to give something quite different; if you strike several notes on the piano, he is unable to tell which is C. Color recognition is much more developed. No one who is not color blind finds any difficulty in picking out a green from a red or a yellow. This lack of individuality in tones is probably the reason why they have never received distinctive names like the colors. They are called by the uninspiring names A, B, C, etc.

A few persons are able to recognize tones as accurately as colors. They can tell whether a piano is tuned slightly above or below the usual standard. This ability is called recognition of *absolute pitch.* It is said that Mozart, when quite young, went with his father to the house of a musician. He tried the man's violin and immediately noticed that it was tuned a quarter tone above his own, which he had left at home. Even among musicians the ability to recognize absolute pitch is rare.

On the other hand most persons recognize quite accurately the *relation* between pairs of tones. When we sing or hum or whistle a tune the tones are sounded in a certain order; it is

[1] Deep and shrill tones are often called *low* and *high* respectively. But these terms suggest differences in intensity — faint (or low) and loud.

[2] This is the standard in scientific work. Musicians generally use another standard, called *international pitch,* in which middle C is 261.

the relation of the successive tones that makes the tune. The ability to hum a tune or to recognize it depends on your recognition of pitch relations, or *relative pitch,* — not on absolute pitch; for the tune is the same whether you start with C or D or any other tone.

The serial relation of tones is also quite different from that of the color series. If you strike middle C on the piano and then the next key to the right, and so on, you will observe that they become continually "more shrill." But if you compare them in pairs, C : D, C : E, C : F, etc., you will find that some of these pairs are more closely related than others. Notice especially C^1 and C^2. [Fig. 40.] They sound very much alike, though they are far apart. The vibration rate of C^2 is just twice that of C^1. This 1:2 relation is called an *octave.* It suggests that tones might be represented by a diagram shaped like a spiral or corkscrew, in which any tone lies immediately above (or below) its octave in the next twist of the spiral.

Suppose we take the tones C^1 and C^2 and all tones lying between them. A great many tones can be distinguished within these limits, but only a few are used in music. On a piano there are seven white keys starting with C^1; the eighth[1] key, C^2, begins a new series. The eight tones included within the octave, taken in pairs, give the principal relations or intervals used in tunes and in musical compositions generally. They are chosen because the numerical proportion of their vibrations appeals especially to the human ear: C^1 has 256 and G^1 384 vibrations per second; that is, the relation of C^1 to G^1 is 2:3; the relation of C^1 to F^1 is 3:4; and so on. If you examine Fig. 40 you will see that the musical intervals within the octave are all represented by rather simple numerical relations — the ratio numbers are small; 15:16 is the least simple ratio.[2] In general, the simpler the numerical ratio of

[1] In Latin 'eighth' is 'octavus,' whence the word 'octave.'

[2] The black keys on the piano are used when we take some other tone besides C as standard; we need extra tones to fill in the larger intervals.

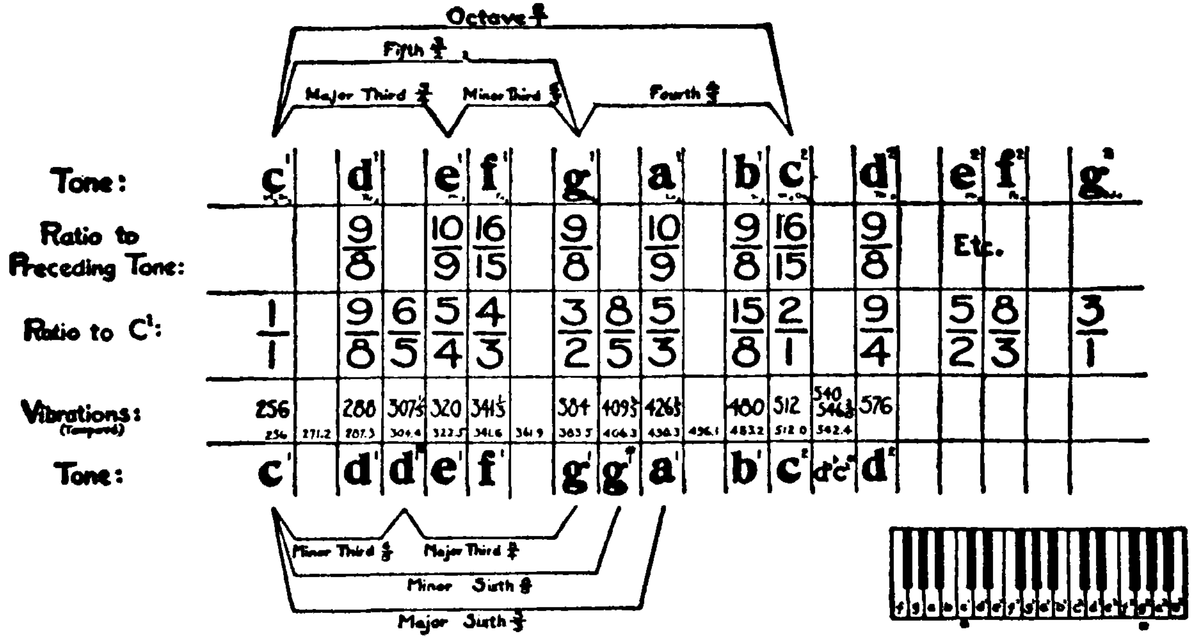

FIG. 40. — MUSICAL INTERVALS

Tones and intervals composing the modern musical scale, showing ratio of vibration numbers. Position of these tones on piano is shown below at right, between the two stars. (Vibration numbers are given according to 'scientific pitch' standard.)

two tones, the 'closer' or 'more harmonious' is the relation, whether the tones are sounded successively or together. This closeness of relation is something quite different from nearness of pitch. The smallest pitch difference in music is the semitone, or minor second, which is the interval between E and F and between B and C. But this interval, whose ratio is 15:16, is musically the least close relation of all.

It is not easy to explain why these tone intervals affect us as they do. The effect is probably due in some way to the hair-cells and rods of Corti; but the full explanation is still uncertain. However, we shall see why intervals bearing a simple ratio are pleasanter than those expressed in larger numbers, when we observe the effects of two or more tones sounded at the same time.

Overtones and Timbre. — When we strike a key on the piano or blow a cornet, the sound waves are not simple. Besides the vibrations depending on the length of the string or tube, there are fainter vibrations corresponding to the half-length, third-length, etc. When we pluck a violin string it vibrates not only as a whole, but in half-lengths if it is plucked one-quarter from the end, and in other part-lengths according to the place where it is plucked. [Fig. 41.]

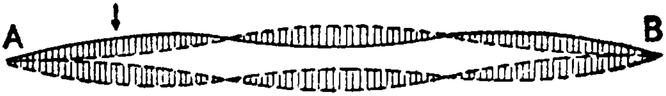

FIG. 41. — HOW OVERTONES ARE MADE

The solid line is a violin string fastened at A and B. Pluck it 1/6 from the end (at arrow) and it vibrates in thirds, besides vibrating as a whole. The part-length vibration is the overtone or harmonic; it is fainter than the fundamental. (The amount of 'waver' is exaggerated in the figure.)

These lesser tones fuse with the main or fundamental tone, and give it a richer effect. They are called *overtones*, because they overlay the fundamental tone. The fundamental with its overtones make a single sound, called a *simple clang*.

Overtones are responsible for our ability to distinguish

between different musical instruments. In some instruments one set of overtones are more prominent, in others another set. This is why we can readily distinguish a wind instrument from a stringed instrument, even if they play the same tune. This individual effect of each instrument is called its *timbre*. The human voice has a great variety of overtones, and each human voice has a timbre of its own. A well-made tuning fork has practically no overtones; it gives the nearest to a pure tone of any instrument.

Differences in timbre correspond roughly to the series of tints in colors. They give us a variety of additional sensations over and above the pure tones. If we take into account these timbre differences, the number of different sounds that we hear is many times greater than 11,000.

Difference Tones. — When two tones are heard at the same time they combine in such a way that their identity is partly lost. This combination effect is called *fusion*. In tonal fusion the tones do not merge together completely; with practice either of the components can be picked out from the total impression. Tonal fusion is due to a different kind of collection of nerve impulses from that which occurs in sight. When different colors stimulate neighboring parts of the retina the sensations are distinct and the only modification that occurs in the combination is the contrast effect.

When two tones (such as C and E) are sounded together, you will be able after practice to distinguish along with them a third tone, called the *difference tone*. Difference tones are produced by the combination of the two sound waves — not by a third stimulus. They arise in this way: Suppose you start with two tones almost alike — say, one of 256, the other of 257 vibrations. Then, once every second the two sound waves will reinforce each other and make a louder sound; and once every second the two forces will be working against each other — one pushing the particles forward, the othes pushing them backward — so that the result will be a softer

sound. This loud-and-soft effect constitutes a *beat*, and the number of beats is always equal to the difference between the vibration rates of the two tones. When a tuning fork of 256 and one of 258 vibrations are sounded together there will be two beats every second; with forks of 256 and 266 there will be ten beats every second, and so on. As the difference between the two tones is increased the beats increase in number, till at length they become so rapid as to be indistinguishable; instead of hearing beats we hear a deep tone, which is the difference tone. The rate of a difference tone is always equal to the difference of rate between the two tones which are sounded together.

So then, whenever two tones differing by more than 16 vibrations are sounded together it is possible to hear three tones — two primary and one difference tone; and when three tones are sounded together we may hear six — three primary tones and the difference tone of each pair; and so on. The primary tones and difference tones fuse together into one complex impression. These complex sensations are called *compound clangs*. A *noise* may be regarded as the limiting case of a compound clang.

Difference tones help to explain the fact that simple ratios in tone intervals are more pleasing than ratios expressed in large numbers. For if the ratio of two tones is simple, the difference tone will be proportional to the primaries: the difference tone of 256 and 320 is 64, which is one-quarter of 256. But if the two tones are not in simple ratio the difference tone will make beats or secondary difference tones with each tone of the pair, and these again will make beats with the primaries. In other words, if the ratio between the two is not simple the result will be a conglomerate mass of jarring vibrations — an unpleasant noise, instead of a clear-cut compound clang.

Intensity and Other Characteristics. — Differences in intensity or *loudness* of sound sensations are due to differences

in the force of the sound waves. The faintest audible sound is produced by dropping a cork weighing 1 milligram[1] from a height of 1 mm., the ear being 91 mm. distant. The upper limit of intensity has not been determined; loud sounds tend to become more and more painful, and in the end produce actual injury to the ear-drum.

Very deep and very shrill sounds are usually not so loud as those in the 'middle range' — that is, those within the compass of the human voice. Middle-range sounds are also easier to *locate*. A deep organ tone seems to fill the air. A shrill tone, such as the chirp of a cricket, is thin and unextended; it is difficult to determine the source unless we see it. Sounds in the middle range of pitch can usually be rather definitely located. The two ears assist considerably in this determination. Sounds on our right give a louder effect in the right ear than in the left. A sound in the medial plane of the body is most difficult to locate correctly. Often a noise that seems at first to come from in front is afterwards found to be behind us.

Importance of Hearing. — The tone series in hearing corresponds to the series of pure hues in sight, and the timbre series to the series of tints. There are about 11,000 pure tones, as compared with only about 160 pure hues, and there are far more grades of timbre than grades of tint, so that altogether we receive a greater variety of simple sensations in hearing than in sight.[2] On the other hand, visual sensations from different points of the retina do not fuse. They are put together into all sorts of *patterns*, corresponding to the objects which stimulate the eye; while auditory sensations give one single composite effect at any given instant; so that the eye furnishes more detailed information of the world about us than the ear.

[1] One milligram (mg.) is about 15 thousandths of a grain avoirdupois.

[2] In spite of the great number of shades, which increases the variety of our visual sensations.

The sense of hearing is chiefly important in two ways: (1) Music adds much to the pleasure of life. The average human being gets more happiness from singing, humming, and listening to music than from looking at landscapes and pictures. (2) Spoken language is received through the ear. It is a readier means of communication among human beings than gesture or written language, which stimulate the eye. Because of this advantage, the evolution of hearing has been a powerful factor in promoting communication and social life in the human race and in developing the higher mental processes (ch. xiii).

3. Smell (Olfaction)

Receptor and Stimulus for Smell. — The organ for smell is far simpler than either the eye or the ear. In fact none of the other sense receptors begin to compare in complexity

Fig. 42. — Nasal Cavity and Olfactory Region

Vertical section of head, viewed from front, passing through the rear part of eyeballs. The olfactory region lies mainly at the upper end of the long narrow passages at each side of the central vertical membrane (septum) of the nose. [From Wenzel.]

with the eye or the ear, except the receptor for the static sense (p. 117).

The olfactory receptors consist of a number of spindle-shaped cells, which are embedded in the lining of the nostrils.[1] They lie far back in the nasal passages. [Figs. 42, 43.] Each olfactory spindle is connected with a fiber of the olfactory nerve.

The stimulus for smell consists of very minute odorous particles which emanate from various objects (especially organic matter) and permeate the surrounding air. They sometimes travel great distances. In blossom-time we can scent the fragrance of a peach orchard from afar. The odor emanations are drawn into the nose in breathing. As they pass through the nostrils some strike the olfactory cells and stimulate them. The stimuli include many varieties of particles which excite different kinds of nerve impulses in the olfactory nerve. The process of stimulation is apparently a chemical action. The neurons of the olfactory nerve starting at the spindles carry the impulses to the olfactory center in the brain.

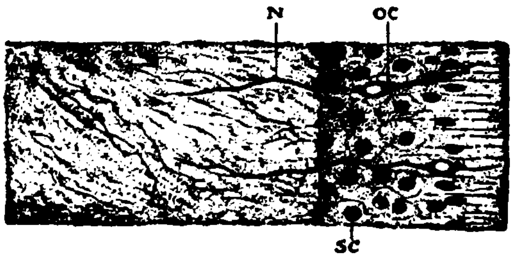

FIG. 43. — OLFACTORY CELLS

Section of mucous membrane within the nose, showing olfactory cells (OC) and nerve fibers (N) which connect with them. SC = supporting cell. [Based on Piersol.]

Odors. — Olfactory sensations are called *odors*. Although the receptor for smell is simple, a great number of different qualities can be distinguished. No complete list of odors has ever been made, and their total number has not yet been estimated. New qualities are often discovered when

[1] The nose is not a receptor, like the eye or ear; it is part of the organ for breathing.

we come across a new fruit or some new chemical compound.

The odors do not form a simple series, like the color hues or auditory tones. They fall into several groups or series, and these are mutually related through intermediate odors. Recent investigation shows that there are six distinct types of odors: Fragrant, ethereal, foul, aromatic, balsamic, and empyreumatic. [Table III.] A typical *fragrant* odor is heliotropine. From pure fragrance there is a series of odors becoming more and more *ethereal*, the odor of geranium being about midway between. There is also a graded series from fragrant to *foul*, and from fragrant to *aromatic;* and so for other pairs.

TABLE III. — CLASSES OF ODORS

Class	*Examples*
1. Fragrant or flowery	Heliotropine, Tonka bean
2. Ethereal or fruity	Lemon, oil of bergamot
3. Foul or putrid	Rancid cheese, carbon bisulphide
4. Aromatic or spicy	Anise, pepper
5. Balsamic or resinous	Camphor, turpentine
6. Empyreumatic or smoky	Tar, pyridine

[After Henning, *Zsch. f. Psychol.*, 1915, **73**, pp. 240–257.]

The relations of odors are represented in the form of a prism [Fig. 44], because the six types can be arranged as corner points of three surfaces, with cross-series between the diagonal corners of each. There are cross-series between the fragrant and empyreumatic, and between the aromatic and foul; and similarly for the diagonals of the other two surfaces of the prism.[1] An interesting case is the odor at the intersection of diagonals. For example, the odor of parsley is midway between fragrant and empyreumatic, and it is also midway between foul and aromatic. The prism diagram means that if you take samples of every different odor and

[1] The prism is hollow — there are no odors represented by points in the inside.

arrange them in this way, there will be *gradual* changes of odor as you sniff the samples in regular order — in no case will there be an *abrupt* change.

Intensity differences in smell depend not so much upon the force with which individual particles strike the olfactory spindles, as on the *density* of the stimuli — that is, on the number of particles drawn into the nostrils at a time. With a uniform rate of breathing the intensity of the odor is greater according to the density of the emanation from the odorous substance. Differences in intensity may be tested by means of a series of bottles containing some odorous substance in different degrees of dilution. The more concentrated the solution, the more particles will emanate from it, and hence the greater will be the intensity of the sensation.

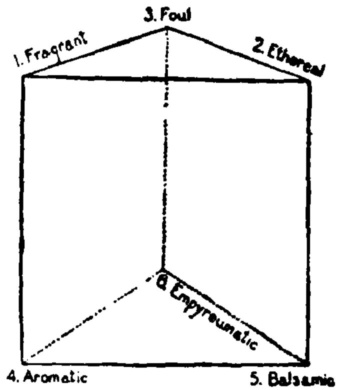

FIG. 44. — ODOR PRISM

Showing relation of the six types of odors to one another. [Modified after Henning and Titchener.]

Intensity tests are also made with the *olfactometer.* [Fig. 45.] This apparatus consists of two parallel tubes, curved at one end for insertion in the nostrils. Tubes lined with substances containing odorous particles are drawn over the straight end of the olfactometer; the intensity of the odor varies with the amount of exposed surface of odor-bearing substance — that is, with the length of the projecting part of the odor-tube.

Either of these apparatus may be used to determine the lower limit of intensity. The least observable intensity varies widely according to the substance used; for mercaptan it is about 0.000,000,043 mg. in a liter of air. This is one of the lowest values: in other words, the smell receptor is more sensitive to mercaptan than to almost any other substance.

Importance of Smell. — Much remains to round out our systematic knowledge of smell. The reason for this backwardness is that smell plays a relatively small part in human life. Pleasant odors are sources of esthetic enjoyment, and unpleasant odors sometimes serve to warn us of danger in the environment. But smell is not especially important, like sight, hearing, or touch, in extending our knowledge of the outer world. Man has not the capacity for fine discrimination in this field. In the dog, the deer, the ant, and certain other species the sense of smell is much more highly developed. Odors are the dog's chief clue in following a trail, where men rely on the sight of footprints, broken twigs, and other visual clues. With man, smell is a luxury or an ornament, not an essential part of his life equipment.

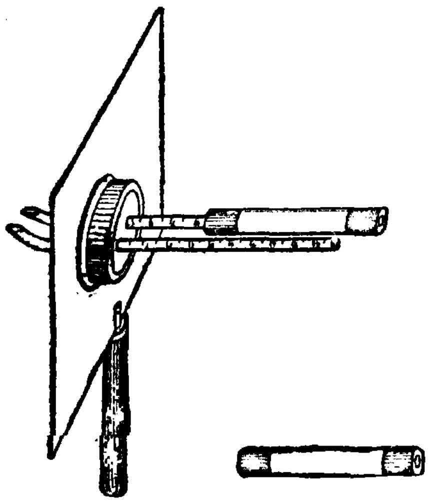

FIG. 45. — OLFACTOMETER

The bent tubes at left are inserted in the nostrils. Tubes lined with some odorous substance are drawn over straight part of tubes at right. Amount of exposed surface is indicated on the scale. The upright screen conceals position of odor-tubes from observer.

Historically this sense arose in connection with the feeding process. It is an offshoot of a primitive *food sense*, which at some point in evolution divided into the two senses of smell and taste. Like other senses, smell came in the course of time to acquire new uses. The deer, for example, detects the presence of enemies by their odors.

The three distant senses — sight, hearing, smell — fill somewhat the same place in the mental life of animals. So it happens frequently that where one of these three senses be-

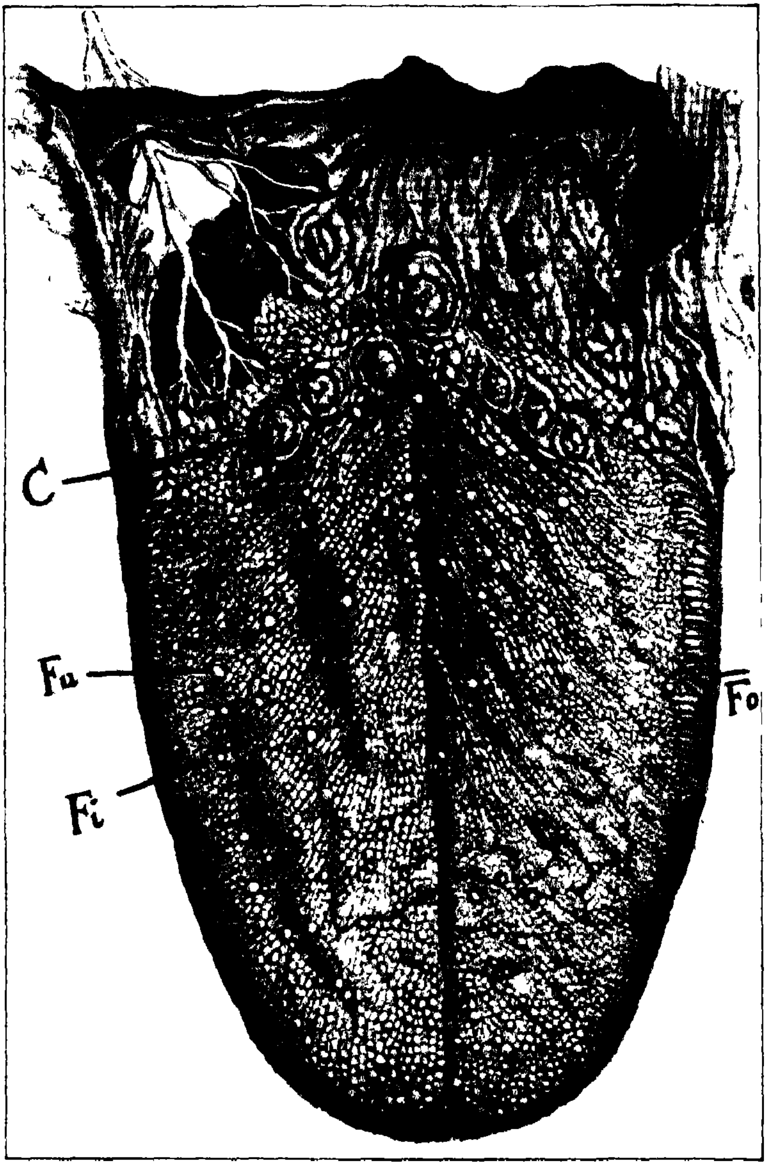

FIG. 46. — TONGUE, SHOWING PAPILLÆ

Taste bulbs are located in the circumvallate (C) and fungiform (Fu) papillæ. None are found in the filiform (Fi) or foliate (Fo). [From Wenzel.]

comes highly developed in a given species, one of the others degenerates. This is the case with smell in the human species. Sight and hearing overshadow it so completely that we scarcely ever rely upon it for help in the important affairs of life.

4. Taste (Gustation)

Receptor and Stimulus for Taste.— We come now to the senses which are stimulated only by objects near our body or in actual contact with it. These are called *contiguous* senses, in distinction from the distant senses. Taste is the most stay-at-home of all the external senses. The tastable substance has to get *inside* the mouth before it can become a stimulus.

The receptors for taste are certain bodies shaped like bulbs or flasks, which are inserted in the mucous lining of the tongue and palate. [Figs. 46, 47.] These bulbs have a small opening or pore at the neck end, which receives the stimulus; the taste cells lie in the walls of the taste bulbs. The stimuli are always in liquid form; solid substances are tasted only when dissolved by action of the saliva. Fibers from three of the cranial nerves connect with the cells in the taste bulbs at various parts of the tongue and convey the impulses furnished by the stimuli to a taste center in the brain.

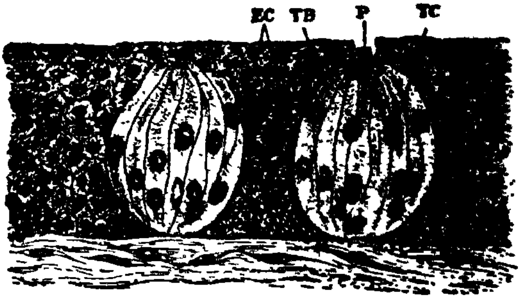

FIG. 47. — TASTE BULBS AND TASTE CELLS

Section of lining of papillæ of tongue, showing taste bulbs (TB), with pore (P) at neck and taste cells (TC) forming part of the bulb; EC = epithelial cells. [Based on Piersol.]

Taste Sensations.— Tastes and odors are often confused. We imagine that certain substances have very pronounced

tastes, which in reality have no taste at all. This is because much of the food which we take into the mouth consists of odorous substances. We breathe while we are chewing, and the odor-particles are carried out with our exhaled breath through the nostrils. Naturally we associate the resulting sensations with the food in the mouth, and regard them as sensations of taste. The real nature of these sensations may be determined by holding the nose while chewing, so that no odorous particle can stimulate the receptor for smell. Such a test will cause many surprises. It will be found that an onion and a potato do not differ in taste at all; their tremendous difference in odor has led us to imagine that there is a difference in their taste quality also. Usually the sense-impression which we derive from food is a mixture of various sensations — chiefly smell and taste, partly also touch and temperature. This mixed sensation is called the *flavor* of food. It is by no means easy to pick out its various components.

The confusion between taste and smell sensations is responsible for the prevalent belief that taste affords a great number of different qualities. The most careful examination indicates only four qualities in taste:

Sweet
Sour (or acid)
Saline
Bitter

Some observers notice two other qualities, metallic and alkaline; these are probably combinations of taste qualities. The four simple qualities do not form a series. They bear no special relation to one another except that sweetness contrasts to a certain extent with the other three.

Intensity differences in taste may be tested by means of bottles containing solutions of some tastable substance in varying degrees of concentration. The solutions are applied successively to the tongue by means of a brush. It is rather

difficult to compare two taste intensities, because the stimuli tend to persist; it requires some ingenuity to remove a tasteful substance from the tongue quickly enough to compare it accurately with the next stimulus. The least observable intensity of taste differs widely for the four qualities. [Table IV.]

TABLE IV. — LEAST OBSERVABLE INTENSITY FOR TASTE

Quality	*Substance*	*Dilution in Water*
Bitter	Quinine	1 : 390,000
Saline	Salt	1 : 2,240
Sour	Sulphuric acid	1 : 2,080
Sweet	Sugar	1 : 199

[From Sanford, *Exp. Psychol.*, p. 48, after Bailey and Nichols.]

Significance of Taste. — Pleasant tastes or flavors add considerably to the enjoyment of food, and unpleasant flavors often enable us to reject what is unpalatable. On the other hand, certain nutritious dishes may acquire an unpleasant association through taste. If you were fed up with prunes as a child, the taste of prunes will be disagreeable to you in later life. Most of us have a distaste of this sort, often a loathing, for certain articles of food which are by no means harmful — which in fact may be very beneficial. It is also true that pleasant tastes or flavors are sometimes obtained from unwholesome foodstuffs. Savages and civilized men alike are prone to overeat of delicious substances which injure the digestive organs.

The information about the outer world which this sense gives us is of some value in life. Yet we cannot but imagine that the taste sense would have been more useful if pleasant and unpleasant tastes corresponded more closely to the nutritious and harmful. On the whole, taste is probably the least valuable of all the senses.

5–7. CUTANEOUS SENSES: TOUCH, WARMTH, COLD

Cutaneous Receptors and Stimuli. — The outer surface of the body is susceptible to several kinds of stimulation which

are grouped together in popular language under the name of 'touch.' In reality there are different receptors for the various stimuli, so that we are bound to treat the skin sensations as forming several distinct senses.

In addition to the *touch* sense, there are senses of *warmth* and *cold*. These two are not merely different qualities but separate senses, as is shown by a simple experiment. Mark off an area 20 mm. square on some one's arm. Take a knitting needle which has been chilled in ice-cold water, and explore this area systematically, marking in ink each spot which the observer reports as feeling 'cold.' When a complete map of the cold spots has been made, explore the same area with a needle warmed in hot water, and mark the warm spots with a different-colored ink. The arrangement of the cold and warm spots is found to be very different.

Every spot on the skin is stimulated by contact and gives a touch sensation. But we find that certain spots give also a *pressure* sensation distinct from *contact*. The arrangement of pressure spots does not correspond to either the warm or the cold spots. [Fig. 48.] This indicates that the three are different senses.

If we examine the structure of the skin with a microscope, we find several different kinds of corpuscles embedded in it and connected with nerve endings. The most noticeable of these in man are the corpuscles of Vater-Pacini, Meissner, Krause, and Merkel. [Fig. 49.] Some of these types lie near the surface; others lie deeper in the skin. It is believed that these several types are receptors for different cutaneous senses.

The receptors for touch, warmth, and cold are distributed over the entire outer surface of the body. There are touch corpuscles at the roots of the body-hairs; they are found also in the eyeball, tongue, and other special organs. Some of the inner organs are sensitive to contact and pressure but not to temperature stimuli.

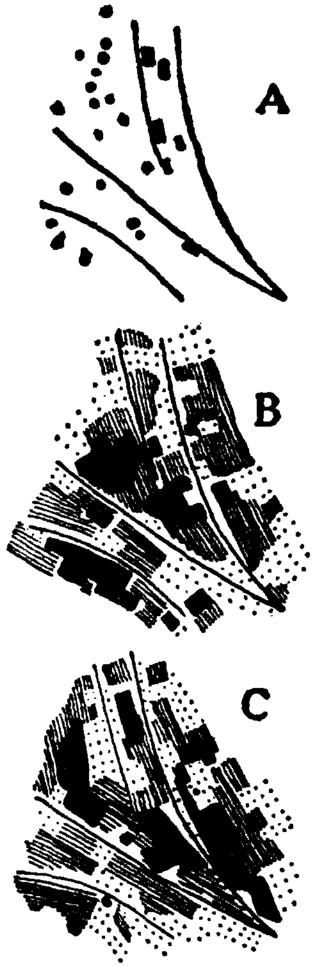

FIG. 48. — PRESSURE AND TEMPERATURE SPOTS

Map of palm of left hand, showing relative distribution of sensitivity to pressure (A), warmth (B), and cold (C). Same area is represented in all three cases. In A the regions marked black are relatively *insensitive* to pressure. In B and C the areas *most sensitive* (to warmth and cold respectively) are marked in black, less sensitive in lighter shading, etc. [From Schaefer, after Goldscheider.]

The stimulus for touch is the contact of any substance with the skin. The stimulus acts mechanically (not chemically) on the touch corpuscles. The warmth stimuli are heat waves that penetrate the skin and act on the receptors for the warmth sense; in order to affect these receptors the temperature of the stimulus must be somewhat higher than the temperature of the skin. The cold receptors are affected by stimuli that are colder than the skin. The cold receptors lie nearer the surface than the warmth receptors and are more readily stimulated.

Cutaneous Sensations. — Each of the two temperature senses has one characteristic quality, called *warmth* and *cold* respectively. When the warmth and cold receptors are stimulated together the result is a sensation known as *heat* sensation.

The sense of touch has two elementary qualities, *contact* and *pressure;* under special conditions of stimulation touch gives rise to certain other quality effects. We distinguish between sensations of *roughness*, *smoothness*, *moving contact*, *moisture*, and *stickiness*. The sensations of *tingling* and *itching* appear to be touch qualities; but they are caused by stimuli within

the body and are possibly organic sensations. The peculiar sensation known as *tickle* differs strikingly from most sensations, in that a very faint stimulus produces a very intense sensation. The tickle sensation is probably due to a definite

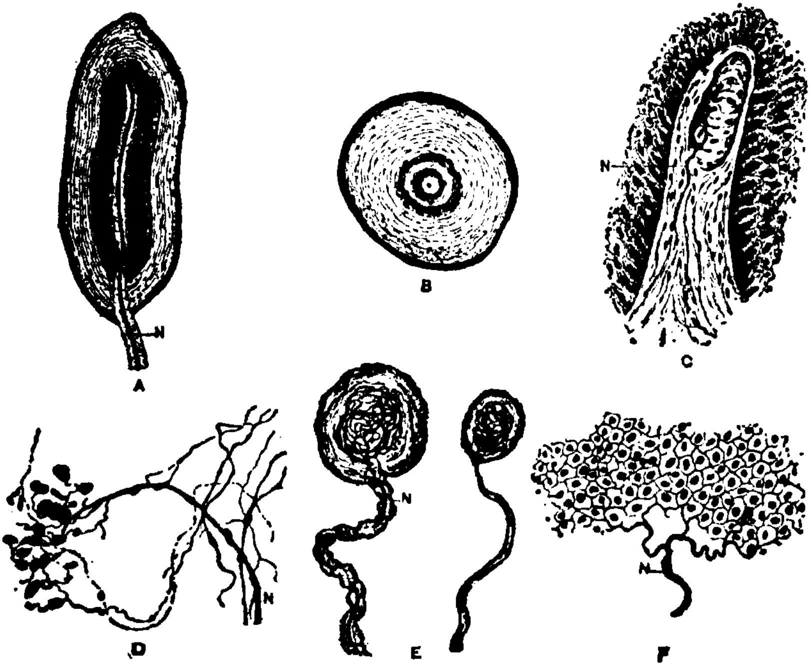

FIG. 49. — CUTANEOUS RECEPTORS

A. Vater-Pacini corpuscle.
B. Transverse section of same.
C. Meissner corpuscle.
D. Merkel cells in interpapillary epithelium.
E. Krause end-bulbs from human conjunctiva.
F. Free nerve endings in epidermis of rabbit.
N = nerve fibers.

touch stimulus applied to a very small area. The other special touch qualities are due to spatial and temporal variations of the stimulus.

Differences of intensity may be examined in touch, warmth, and cold by methods similar to those used in the higher senses. The least observable intensity in touch is stated to be

the contact of a cork weight of 2 mg. on the tip of the finger. For the temperature senses the least observable sensation is produced by a stimulus about one-eighth degree warmer or colder than the temperature of the skin.

Importance of the Skin Senses. — While the cutaneous sensations furnish no great variety of quality, the fact that their receptors are spread over the entire body gives them great importance in life. Touch sensations inform us of the location of things which press against the skin. They help us considerably in acquiring knowledge of the shape and size of objects, and in perceiving motion and other space relations (ch. vii).

Warmth and cold are far less significant than touch. They rarely occur apart from touch sensations, and usually combine with these, just as taste and smell sensations combine together. The information which the temperature senses give is useful so far as it goes; these senses are undoubtedly more important for life than taste. It is interesting to notice that warmth (and to a lesser degree cold) is in a rudimentary way a distant sense. We feel the warmth of a glowing stove at some distance, and we can sense the cold of ice before the hand quite touches it.

8. Organic Senses (Cœnesthesia, Visceral Senses)

The Systemic Senses. — We have examined the 'five senses' recognized by popular tradition, and in doing so we have discovered two more — warmth and cold — which were improperly identified with touch. All these seven senses are stimulated by *external objects* and forces. They give us information concerning situations and occurrences outside our own body.

There are also two senses which inform us of conditions within the body and of what is taking place there: (1) The *organic senses* report the general condition and workings of our organs of digestion and other internal organs. (2) The

pain sense reports injuries which happen to our body and which may be due to either internal or external causes. The two, taken together, are called *systemic senses*, because they report events that occur in our bodily system.

Information about our bodily processes is quite as important a factor in life as knowledge of the outer world. The organic and pain senses do not deserve to be ignored as they used to be. The student of psychology who insists on recognizing only the traditional five senses ought to be inflicted with a jumping toothache till he admits at least a sense of pain.

Organic Sensations. — The organic senses are extremely difficult to investigate, because their receptors lie buried so deep within the body that they are generally inaccessible to examination. Our knowledge of them is very imperfect. Not only is it difficult to determine exactly the number of different sensation-qualities that they furnish, but it is uncertain how many of them have different kinds of receptors and are really separate senses.

There are at least four important sorts of organic sensations: (1) digestive sensations, (2) vascular and respiratory sensations, (3) generative sensations, and (4) feeling tone. The first three are connected with the operation of the great systems of life functions after which they are named. Feeling or hedonic tone is apparently due to metabolic[1] conditions within the body.

Among our *digestive sensations* the most easily distinguished are *hunger* and *thirst*. Under careful examination the sensation of hunger proves to be a complex affair. It includes hunger *pangs*, due to muscular contractions in the stomach; appetite or *craving* for food, which sometimes occurs even when the stomach is filled; general discomfort due to *starvation* and depletion of the tissues. A distinct sensation quality

[1] Metabolism includes various chemical changes, especially the destruction and restoration of tissue.

accompanies the satisfaction of hunger. Thirst is probably due to drying of the mucous membrane in the mouth and throat. Another digestive sensation is *nausea*, which has a very pronounced quality. There is also a special sensation in the digestive tracts due to distension of the stomach and other cavities. Less definite sensations accompany the later digestive processes in the intestines, bladder, etc. There are also sensations connected with urination and defecation. Associated with the digestive sensations is a sensation localized in the abdominal region, which is stimulated under emotional conditions of fright, anger, affection, etc. Although the various sensations just described are all associated with the digestive processes, they are due to distinct stimuli and in some cases probably involve different kinds of receptors.

The *vascular* and *respiratory sensations* are less varied and much more obscure. The circulation of the blood is accompanied at times by distinctive sensations such as flushing, heart quavers, throbbing, and tingling of the blood. Breathing is often accompanied by an unnamed sensation of 'expansion,' or its opposite, 'stuffiness.' Sensations from circulation and respiration are present in states of trepidation, anxiety, and panic. But for the most part the autonomic bodily processes go on without any sensations except a feeling tone.

The reproductive organs furnish a number of distinctive *generative sensations*. These include the sensations of sexual craving, sexual excitement, orgasmic sensations, and sexual satisfaction. The generative system also contributes to the general feeling tone of the body.

Feeling tone is a vague sensation which often accompanies other sensations. It includes two opposite qualities, *pleasantness* and *unpleasantness*. It probably has no special receptor of its own, but is due to certain characteristics common to all the stimuli which act upon the organic receptors.

The chemical (metabolic) changes which take place in the body are of two opposite sorts — constructive and destructive processes. New cells are built up and the wastage of cells is restored; this process is called *anabolism.* Cells are destroyed or impaired by use, giving the opposite process, *catabolism.* The organic sense receptors are affected by these two kinds of life processes as well as by their own special stimuli. That is, organic stimuli, whatever else they may be, are either anabolic or catabolic; so that any organic sensation, besides having its own quality (hunger, heart throb, craving, and the like), has also a *feeling tone,* which is pleasant if the stimulation is anabolic and unpleasant if it is catabolic. Draw a series of slow, deep breaths and you will notice a growing feeling of pleasantness in the region of the lungs. Notice the gradual onset of unpleasantness which accompanies nausea. In each case the feeling tone is different from the special quality of the sensation.

The external sensations have a certain degree of feeling tone also. Many sounds and tastes are noticeably agreeable or disagreeable. A man will almost sell his soul for a luscious peach, and sometimes he is quite ready to murder an ear-racking organ-grinder. But in the external senses the special quality of the sensation is so pronounced that the feeling factor is usually of secondary importance. On the other hand, most of our digestive and other organic sensations are observed chiefly as a feeling tone of pleasantness or unpleasantness; their own special qualities are subordinate.

Besides the feeling tone connected with various senses, we experience a *feeling of general sensibility,* or *general feeling tone,* in the body as a whole. This general feeling varies from time to time. It gives sensations of well-being, vigor, buoyancy, repletion, drowsiness, discomfort, fatigue, weakness, and the like. Our general feeling tone at any time is a highly important factor in our mental life. The dyspeptic and the athlete live in two very different worlds, even though they

room together. Our actions are not merely responses to the 'midst' in which we are placed; they reflect our own organic condition as well. We shall notice this especially when we examine emotion and emotional attitudes (chs. ix, xv).

9. Pain (Algesthesia)

Pain Sensations.— The pain sense is like the organic senses in that it gives us information concerning the state of our own bodily tissues and organs. But it is an independent sense; its receptors are different and it gives a quality of sensation very different from the organic or any other sense.

The pain nerves form an exception to sensory nerves generally, in that they are not provided with any special receptors. Their endings in the skin are unattached and are called *free nerve endings.* [See Fig. 49 F.] One might say that they keep open house for any stray stimuli that are wandering about in the body. This is true in a way, but it needs qualification. There are no stray stimuli in the body, except the overflow of very intense stimuli which are too powerful for their proper receptors to manage. Very bright light, very intense heat, give more energy than the receptor for sight or warmth can absorb; the surplus energy spreads destruction through the neighboring tissues. The free endings of the pain nerves take up these vagabond stimuli and the resulting nerve impulses travel up to special pain centers in the brain.

Pain sensations have a distinctive quality of their own; pain is pain, whatever its source. But there are many sorts of pain, each of which bears the mark of its origin. We distinguish between scratches, pricks, stings, and sores (touch); burns (temperature); stomach pains, nausea, intestinal pains (organic); bruises and muscular soreness (muscle sense). Certain eye pains are tactile; others are due to strain of the eye muscles (muscle sense); occasionally eye pain is

due to intense light. Toothache is due to stimulation of certain nerves which originate in the teeth. Shooting neuralgic pains are apparently due to internal stimuli which affect the nerves at some point in their course.

There is always a marked feeling tone of *unpleasantness* in the pain sensation. The fact that pain stimuli are destructive to the bodily tissues (catabolic) would account for this. The connection between the pain quality and the unpleasantness quality is so universal that we find difficulty in distinguishing them. It is much like the confusion between tastes and odors, except that in the latter case we can readily bring out the distinction by holding the nostrils closed. The discrimination between pain sensation and unpleasant feeling is not so easy. It requires considerable practice in observing our sensations carefully before we can say, "This sensation is unpleasant, but it is not a pain."

However disagreeable the pain sensations may be, the sense itself is useful. It serves to warn us of dangers, both outside and inside the body; it often enables us to avoid or remedy harmful situations. In the course of animal evolution an elaborate system for receiving pain impressions has been built up. In the higher species the pain sense is an important factor in life. Far from making the responses of dogs and other animals less suitable to the general situation, pain sensations usually help the creature to do the best thing in the circumstances. The same is true of man. It is a mistaken psychological attitude to regard pain as an evil or mental error. Pain is part of our equipment for meeting the situations that confront us in life. It is an important factor in adjusting our behavior to unfavorable conditions in the environment.

10. Muscle Sense (Kinesthesia, Kinesthetic Sense)

The Motor Senses. — We have examined the two great groups of senses: those which give information concerning

external objects, and those which report *conditions within our own body*. We now come to a third group: the senses which give information regarding our *bodily movements* and which indicate the position of our body in space and the relative position of its various members. For want of a better term this group is called the *motor senses*, although they indicate position as well as movement. The motor senses include (1) the *kinesthetic sense* or senses, usually known as the *muscle sense*, and (2) the *static* or *equilibrium sense*.

Muscle Sensations. — Kinesthetic or muscle sensations are obtained through sensory nerves which start in the muscles, tendons, and joints. These nerves are provided with special receptors which are stimulated by contractions of the voluntary (striate) muscles. The muscle sensations may be observed by moving the finger, elbow, knee, eyelid, eyeball, or tongue, and noticing how the movement feels; the sensation is quite different in quality from the sensation of contact or pressure. In certain diseases the patient is unable to feel pressure, but has distinct sensations of movement; in other cases the opposite is true.[1] This establishes the existence of 'kinesthesia' as a separate sense or senses. It has not been determined whether the tendons and joints yield different kinds of sensations from the muscles. The term *muscle sense* is commonly applied to the whole group of kinesthetic sensations.

These sensations give information not merely of bodily movements, but of the position of our members in space, of how they are bent, etc. When a member is held rigid in any position, each of the antagonistic muscles is subject to a certain amount of contraction; the two resulting sensations taken together indicate the relative amount of muscular contraction and hence the position of the member. This may be observed if you close your eyes and hold your bare arm in

[1] If you wake up at night with your arm *numb*, try to move it, and then touch it. Is it the muscle sense that is benumbed, or touch?

some position where it does not touch the body, or if you twist your neck to the right or left and keep it in this position; the muscle sensations tell you what its position is.

Muscle sensations are usually reinforced by touch sensations, such as the scraping of the clothes against the skin, and by indications from other external senses. When the eyes are turned from side to side, the motion of the whole field of objects across the retina brings about a general change of visual sensations; in walking we have a visual picture of the moving scene. These auxiliary motor indications from the external senses (touch, sight, hearing) are not really kinesthetic sensations, but they assist materially in the perception of our posture and movements; they may be termed *secondary motor sensations.*

There are few differences of quality in the muscle sense. When we are actively pushing or lifting a heavy object, we obtain a sensation called *effort;* when a member is resisting external pressure there is a sensation of *strain.* These sensations are assigned to the tendons. When the muscles have been active for a long time there arises a sensation of muscular *fatigue;* this is possibly a form of feeling tone.

The *intensity* differences of muscle sensations are very pronounced and are finely discriminated. A slight movement of the finger or arm is readily observed; the movements of our limbs are regulated very accurately by means of these indications. This may be easily tested by observing how many different positions of one of your fingers you can discriminate when your eyes are closed. The least observable difference of position for the middle finger is found to be 1°.

The muscle sense not only serves to inform us of our various postures and movements, but it also gives information regarding the weight of external objects. If we start to lift a heavy suitcase or push a piano, the resistance which it offers checks the speed of our muscular contraction; the intensity of the muscle sensation is greater than when we merely raise the arm.

11. Static Sense (Equilibrium Sense)

Static Receptor and Sensations. — The *static* sense is another source of information concerning the position and movements of our body. It has nothing to do with the muscles and is entirely distinct from the muscle sense, though the two work together. The static receptor is a complicated structure in the inner ear, consisting of the *semicircular canals* and *sacs*. The canals are three in number, and are placed at right angles to one another in three different planes. [Fig. 50; cf. Figs. 36, 37.] They are bony in substance, and in shape resemble a horseshoe. The canals are situated in the labyrinth of the ear, lying slightly above and to the rear of the cochlea. Each canal is filled with a liquid called *endolymph*. Receptor cells with long projecting hairs line

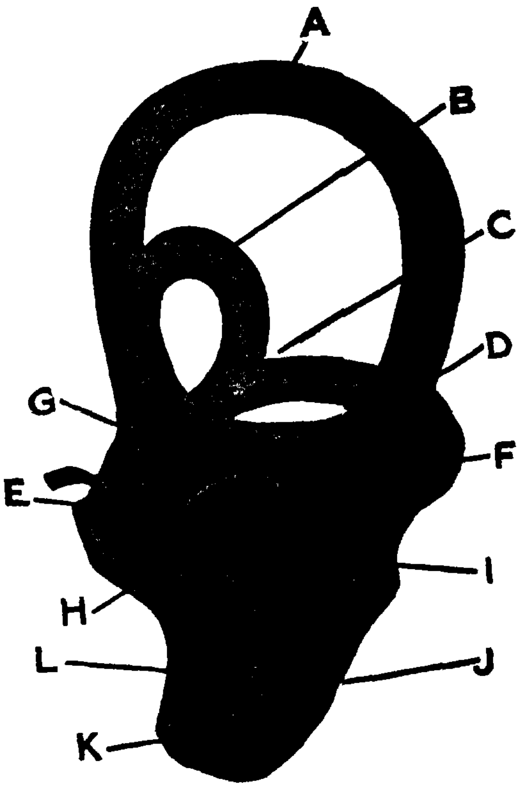

Fig. 50. — Semicircular Canals and Sacs

Section through vestibule of left ear. (Compare Fig. 37 for right ear.) Canals are shown above, the sacs in middle, beginning of cochlea below. A = superior canal; B = posterior canal; C = horizontal canal; D, E, F, = ampullæ of three canals; G = utricle; H = saccule; I = oval window; J = beginning of scala vestibuli; K = cochlear duct; L = scala tympani, ending in round window beneath. [From Wenzel.]

the walls of the canals. The two sacs, the *utricle* and *saccule*, are rounded protuberances situated in the vestibule near the canals. They contain minute crystals called *otoliths*. The canals open into the *utricle;* at the base they enlarge and form the *ampullæ*. The *saccule* lies just below the utricle.

The *stimuli* for static sensations are the flow or pressure of the endolymph inside the canals, due to changes in the position of the head. The otoliths in the sacs are also affected by changes in the endolymph. The relation between the canals and the sacs is not clear, but it is probable that the canals give us information of motion and rotation, while the sacs indicate the position of the head in relation to gravity.

Since the canals lie in three different planes, any angular change whatsoever in the position of the head involves rotation of at least one canal. When the head is turned horizontally to the right, inertia causes the liquid in the horizontal canal to circulate toward the left; when we turn the head to the left the direction of circulation is reversed. If the whole head is moved forward, backward, or to one side, as in walking, the pressure at *both* ends of some canal is increased or diminished. These changes in the endolymph stimulate the sensitive projecting hairs and this excites the neurons of one branch of the eighth cranial nerve — the same nerve whose main branch is used for hearing; the nerve impulses are carried to the static center of the brain.

The canals were formerly supposed to be connected with the sense of hearing. But it is found that when a pigeon's canals are removed the bird is unable to maintain his balance or regulate his flight. Tracing back the evolution of the two organs in the animal scale, it is found that the static organ arose *before* there was any sense of hearing; curious though it may seem, hearing is an outgrowth or offshoot of the static sense. In man and other high species hearing has developed much further than the static sense and has far outstripped it in importance.

The static sense gives sensations of *position* and sensations

of *motion*. In both cases the static sensation is so closely bound up with muscle sensations and other motor information that it is difficult to distinguish its own particular quality. The sensation of motion apparently differs in quality from the sensation of position. The sensations from the three canals may differ slightly in quality also. Nausea is an organic sensation due to some connection between the digestive organs and the static nerves. Dizziness is, in part at least, due to eye movement.

The differences of *intensity* in static sensations may be observed by lying flat upon a rotation table, with eyes closed, while the table is turned at various rates of speed. The least observable motion is a rate of about 2° per second, starting from a standstill. The stimulus for static sensation is the *acceleration* of motion, not its velocity. If we are rotated on the table at a uniform rate, the sensation gradually dies away; then if we twist the head in any direction the sensation immediately starts up again.

Static sensations, muscle sensations, and the perception of movements through sight and other external senses combine to give us information of our bodily postures and movements. This mass of motor information is the basis of our motor adjustments and plays an important part in the formation of our motor habits.

Significance of Sensation in Mental Life. — It cannot be too strongly impressed upon the student of psychology that all eleven senses must be reckoned with. Of the five traditional senses, taste and smell are far less important in life than the two motor senses and pain. It is especially useful to keep in mind the three great groups of senses — *external*, *systemic*, and *motor*.[1] These three types of sensation bear essentially different relations to mental life. They are the basis of three different sorts of mental activity.

(1) The external senses furnish information which leads to perception, remembering, and thinking; the sensations from

[1] See Table I, p. 58.

these seven senses make up our *cognitive* experiences, or *intellect* — the *knowledge* side of our mental life. (2) The systemic senses furnish information concerning our internal organic processes and bodily condition; they are the source of our *affective* experiences — our *feelings*. (3) The motor senses furnish information as to the position of the various parts and members of our body in space, and the direction and rate of our movements; they are the basis of our *active* experiences — our *will*.

The separate sensations are not experiences; they are the elementary bits of information which combine to make up our experiences. Any conscious experience — perceiving a landscape, the feeling of happiness, the sense of making a sweeping arm-movement — is composed of a number of separate sensations which are combined together by the collecting of separate nerve impulses in the brain centers. Our various experiences, taken together, make up our conscious mental life.

PRACTICAL EXERCISES:

22. Listen for difference tones and overtones on the piano (or some other musical instrument) and describe the experience.
23. Observe the sensations of taste from various common foods while holding the nose, and compare with the usual sensations.
24. Make a map of warmth and cold spots as described on page 109.
25. Compare three different sorts of systemic sensations, e.g., hunger, general bodily fatigue, toothache.
26. Observe your muscle sensations (*a*) in bending the elbow and fingers, and (*b*) in lifting a weight. Compare these with the accompanying touch and pressure sensations.
27. Test your static sensations on a rotation table or in a swivel chair. Spin on your heel (*a*) with head erect, (*b*) with head inclined to right, left, or forward; observe the resulting sensations. Look in a mirror on a moving train, shutting out direct sight of the landscape; observe especially your sensations when the train starts or stops, and when it goes round a curve. Report the results of these observations.

REFERENCES:

On the receptors: Ladd and Woodworth, *Physiological Psychology*, Part I, ch. 8.

On sensations: E. A. Schaeffer, *Textbook of Physiology*, articles 'Cutaneous Sensations,' 'Muscular Sense,' 'The Ear,' 'Sense of Taste,' 'Sense of Smell'; M. Greenwood, *Physiology of the Special Senses*, chs. 2–9.

CHAPTER VI

CONSCIOUS LIFE

Review.—This is a good place to stop and glance back over the ground so far covered. We started with the notion of psychology as the science which investigates the responses of living creatures to the stimuli that affect them. It includes the study of the entire chain of events beginning with stimulation and ending with responsive activity. These processes are carried out by means of the nervous system and the receptors and effectors which lie at either end of the nervous arc. The whole series of events make up our mental life.

Any single episode in our mental life may be divided into three successive stages: (1) We receive piecemeal impressions from the outer world or from our own body. (2) We put these detached pieces of information together and prepare to respond in an orderly and appropriate way. (3) We send out nerve impulses to the muscles and glands, which thereupon perform the proper movements or reactions.[1] These three parts of the process are called *stimulation* (or *reception*), *adjustment* (or *integration*), and *response.*

The first stage, receiving the separate bits of material (sensations), was examined in the two preceding chapters. The senses are the means by which all our impressions are originally obtained. (There are also some secondary impressions, *memories*, which are only indirectly due to the senses.) The sense organs or receptors are stimulated by light waves, sound waves, pressure, and other physical forces, and the

[1] This sounds somewhat mechanical and artificial, because it attempts to describe moving, flowing events in a piecemeal way. If you examine any one of the pictures of a galloping horse which enter into a motion picture scene, the horse's position appears ridiculous — each momentary attitude is very different from your total impression of galloping.

sensory nerves conduct the resulting nerve impulse to a center — in most cases to a brain center. In this way we *receive sensations.*

Sensations would be detached, piecemeal experiences, if the sensory impulses which cause them were not collected and integrated in the brain centers. This is the second stage of the mental process. In the next few chapters we shall see how the *separate elementary sensations are put together* so as to make actual conscious experiences.[1] Perceptions, memories, emotions, thoughts, and other experiences are such integrations; they are due to the orderly combination of separate sensations, and to various changes which take place in connection with the combining process. We shall examine these different sorts of experience in turn. But they will be easier to understand if we explain first of all what is meant by *consciousness* and how our conscious life is related to the working of our brain.

Consciousness and Subconsciousness. — Consciousness is one of those notions that are perfectly plain to everyone, and yet are not easy to explain. It is like the idea of beauty in this respect. You know that a certain statue or painting or symphony is beautiful; but you cannot describe precisely what 'beauty' is. One cannot inject beauty into a thing with a syringe. Something in the make-up of the work of art gives it the quality of beauty. Add a line, take out a line, change a line in a drawing, and its beauty is gone; and yet beauty is not a line or a group of lines.

Like beauty, consciousness is a quality or characteristic of things — it is not itself a concrete thing. Consciousness is not something poured into the mind; it is a characteristic of mental life. Given the proper conditions and there is consciousness. Alter the conditions and there is no consciousness — just as in the case of beauty.

[1] The third stage, the process of *acting and responding*, is treated in chs. x–xii.

Nothing has given more trouble to the beginner in psychology than the notion of consciousness. The word itself is mysterious and forbidding.[1] It is well to recognize this difficulty at the start and try to get better acquainted with the term.

To be conscious, means simply *to have sensations and any sort of experiences.* You are conscious when you are receiving impressions and putting them together into perceptions, thoughts, and the like. When you are in a swoon or a dreamless sleep and are getting no impressions, you are not conscious. In other words, consciousness is merely a shorthand term used to express the fact that perceptions, thoughts, and the like are *part of one's personal mental life.*

We are conscious only when stimuli start nerve impulses and these impulses reach the brain. There are cases where stimuli excite nerve impulses which do not reach the cortex; in such cases we are not conscious, though the stimuli produce important reflex results and consequently belong to the realm of psychology. The reflex eye-wink is an example of this. In many cases the sensory nerve impulses are integrated in the brain centers and cause coördinated responses, yet the impressions are not joined up with our general train of conscious experiences. When we are walking with a friend and are busy talking, we do not notice the objects about us; yet we step up and down and avoid obstacles quite as well as if we were fully aware of our surroundings.

Experiences which form part of our life of stimulation and response, yet do not enter into our *personal* mental life, are called *subconscious.* Our subconscious mental life is quite as important for psychology as consciousness. The lower brain centers are constantly receiving sensory impressions and

[1] Some psychologists get around the difficulty by dropping the notion of consciousness altogether and studying *behavior.* The result is a rather fragmentary science. It is like trying to study art and ignoring the notion of beauty.

sending out motor impulses that are never associated with our conscious life. Many of our thoughts and decisions are determined in large measure by previous subconscious experiences. All the activities of the nerve centers, whether conscious or subconscious, must be reckoned with in psychology; they are all factors in determining our responses.

The Brain and Consciousness. — The really difficult problem is not what consciousness is, but how it is related to brain activity. In discussing each of the senses we traced the course of the nerve impulse from the receptor to the center. When an impulse in the optic nerve reaches the visual center, we see. When an impulse in the auditory nerve reaches the auditory center, we hear. And so for each of the other nine senses. But just *how* the brain activity produces sensations, memories, and other experiences is not known.[1]

This much seems certain: Every single perception and every step in our thinking means *some definite nervous activity.* Our thoughts never for an instant proceed without brain activity. If the brain is in any way impaired, thinking or memory or perception or some other mental process is disturbed. Insanity is caused by some injury to the brain. Lapses of memory, swooning, sleep, are brought about by temporary changes in the condition of the brain.

Psychology need not be tied to any special theory of *how* brain and consciousness are related. But the facts just mentioned point to the conclusion that whenever we think or perceive, our brain is acting in certain corresponding ways. In other words, the psychologist can study his thoughts and memories, his perceptions and emotions, in place of the central nerve processes which accompany them. We have no means of measuring brain processes as we can measure light

[1] There are several theories which attempt to explain the relation. The older view is that the mind is *in* the brain, and that mind and brain *interact.* A newer theory is that thought and brain activity are really the *same* event, observed in two different ways.

waves or muscular contraction. The investigation of our own experiences supplies this lack.

Self-observation. — One of the most important things in studying psychology is to examine your own experiences, or states of mind. The basal facts of psychology were discovered by men observing their own thoughts and perceptions, and reporting what they observed. This method of study is called *self-observation*, or *introspection*.

At first glance it seems simple enough to observe our own experiences. We have them with us constantly and need only direct our attention toward them. Yet when we try it out we find that it is not easy to attend to our experiences carefully and faithfully or to report our observations accurately. The old error about the five senses persisted through many generations. It was kept alive because men did not examine their experiences carefully. They reported not what they observed for themselves but what they had read and heard.

Just as bad mistakes have been made in other sciences and have retarded their development. In physics men persisted in believing that heavy bodies fall faster than light ones; in chemistry they stuck to the idea that there are only four elements — earth, air, fire, and water. These notions seemed so self-evident that for a long time no one took the trouble to put them to actual test.

In psychology the material is so very accessible that the student is slow to realize that training is needed before he can observe it properly. Some of the most absurd mistakes in psychology examinations occur in answering questions for which the student has the material right with him: for instance, he has only to wink his eyes to observe after-sensations. Casual or haphazard noticing of our own experiences is not scientific psychology. Self-observation, as a scientific method, means careful and often minute *attention* to the flow of conscious experiences; it means also giving

exact reports of our observations. Both demand considerable training before the results are accurate. If the student has carefully performed the practical exercises in the previous chapters, he will already have advanced a considerable way in the art of self-observation.

How Conscious Experiences are Formed. — When sensory nerve impulses reach the brain centers, they are combined and altered in many ways before the motor nerve impulses are ready to start a coördinated movement. When we enter a shop our eyes are stimulated by many objects which give us a great mass of color sensations. These elementary bits of sensation are combined at once into vivid perceptions of the various objects in the shop; the perceptions start a train of thoughts and memories which continue until we decide which way to turn and what things to examine and purchase.

Sensations are merely the bits of material out of which our experiences are constructed. The quality and intensity of the separate sensations depend on the nature of the objects which stimulate the receptor organs, and on the nature of the receptor organs themselves, far more than on the nervous system and its activity. Certain visual sensations are 'red' because red-giving light waves strike the eye and because the retina is capable of distinguishing these rays from others. Certain sensations are 'loud' because intense sound waves strike the ear and make the ear-drum vibrate vigorously. This is true of all sensations.

But when we examine the *experiences* built up out of these sensation elements the opposite is true. Their composition depends far more on nervous processes than on the stimuli. The nervous operations which result from the various properties of nerve substance,[1] are the principal agencies in forming our experiences. For instance, conscious attention varies with nervous fatigue: fatigue of the nerve substance in the brain means inattention; restoration of this substance

[1] These were described in ch. iii; see pp. 44–48.

means attention. Memory or revival of old experiences varies with the nervous operation of retention. Association of ideas depends on nervous conduction. There are important conscious operations, or *mental processes*, corresponding to each of the principal properties of nerve substance (ch. iii).

Mental Processes: Impression and Suggestion. — The two most prominent mental processes are that we are *impressed* by objects and events, and that one experience *suggests* another. Impression corresponds to nervous excitation and suggestion corresponds to nervous conduction.

Impression means that a sensation or some other experience is aroused. It occurs when the central neurons are excited by nerve impulses. You see this book — you get a visual impression of it. The impression is due to nerve impulses from the eye which excite the visual center in your brain. Anger is an experience that arises when nerve impulses from your bodily organs and motor organs excite some of your brain centers. And similarly for other experiences.

Suggestion is a form of mental association: one thought passes over into another. The thought of peaches suggests to me the island of Corfu, where I tasted specially delicious peaches. The peach thought and the Corfu thought are associated together; that is, the thought of peaches passes over into the thought of Corfu. In terms of nervous activity what happens is that the nerve impulses pass from one center to another, where they assume a different form.

Revival and Attention. — *Revival* and *attention* are two other mental processes. Revival or *memory* corresponds to the nervous process of retention. The set or trace left by previous nerve impulses in the brain centers makes it possible for these centers to be aroused later in the same way; the form of the earlier impulse is reproduced because of the trace which it leaves behind. Memory images are the conscious experiences which arise as a result of this revival; they are reproductions of earlier impressions. You remember a cer-

tain birthday party because the brain centers which retain traces of that group of experiences have been excited again, renewing the experience to a certain extent.

Attention is related (inversely) to the nervous process of fatigue. Some parts of an experience are more vivid than others. When you are reading, the printed words are vivid. Sounds that occur at the same time are not attended to; — the stimuli may be quite *intense*, but the experiences are not *vivid*. The rubbing of your clothes and other incidental stimuli are generally unnoticed. In reading you attend to only a few words at a time; the rest of the page is scarcely noticed. All this means that out of the many stimuli which occur at any moment, only a few send impulses straight through to your brain centers without hindrance; the others are blocked by resistance due in part to fatigue or exhaustion of certain synapses — they are not attended to. The greater the fatigue, the greater is the degree of inattention.

Attention means the *focusing* of certain impressions. Other impressions that occur at the same time are out of focus; they are said to be in the *margin* or *fringe* of consciousness. The different degrees of vividness or focusing that characterize the several portions of our total experience at any given moment depend on variations in the chemical conditions of the several neurons concerned. In other words, the vividness of an experience depends not so much on the strength of the stimulus, as on the condition of our brain. Attention is partly involuntary and partly under our own control. A very loud sound will force itself upon us and drive all else out of the focus; on the other hand a faint impression may be brought voluntarily to the focus if it is of special interest; the football player sees distinctly certain slight movements on the part of his opponents, which give a clue to the play.

Composition and Discrimination. — The third pair of mental processes are composition and discrimination; they

correspond to the collection and distribution of nerve impulses. The *composition* of sensations into larger experiences occurs when the impulses from several distinct nerve paths are collected together in a single center.

There are two different sorts of mental composition: *fusion* and *colligation*. In *fusion* the elementary sensations are so merged together that it is difficult to pick them apart. The experience is a total consolidated effect. A typical case of fusion occurs in musical chords. The stimuli for the chord C-E-G are three separate tones. When they are all struck together, the resulting sensation is a single, compound clang, in which the three tones are so fused together that only a practiced musician can pick out any one of them from the harmony.

Colligation is another sort of composition, in which the individual components keep their identity. It occurs notably in sight. A painting does not appear to be a patchwork of separate colors on a canvas; we see it as a single picture, representing some definite scene. In colligation it is easy to distinguish the different parts; they do not merge, as in fusion, but appear side by side, as a pattern or picture.

Touch impressions generally unite by colligation; taste and smell by fusion. Sensations from different senses, due to the same object, fuse together. Fried mushrooms are round and brown, odorous, sweet, warm, and soft; it is not easy to separate any one of these sensations from the total effect of a 'luscious food.' A crowbar always *looks heavy* to you if you have once tried to lift one. The fusion is so strong that the visual and muscle-sense elements stick together even when you look at it without lifting it.

Discrimination occurs when a nerve impulse in the central region is distributed into two or more different paths. The mental process is a separation of two or more elements in a given experience. It is the opposite of composition. In looking at a person's face we first see it as a single object.

By the process of discrimination we *pick out* the eyes, nose, mouth, and other features.[1]

All our experiences are made up of elementary sensations which have been 'whipped into shape' by these mental processes. In examining the various sorts of experience we shall have to refer constantly to these operations. They are brought together in Table V, with the corresponding nervous processes.

TABLE V. — FUNDAMENTAL CONSCIOUS OPERATIONS

Conscious Operation	*Nervous Operation*
Impression (sensibility)	Excitation
Suggestion (successive association)	Conduction
Revival (memory)	Retention
Attention (vividness, focusing)	Fatigue
Composition (simultaneous association)	Collection
Discrimination	Distribution
Transformation (mental chemistry)	Modification

Kinds of Experience. — Any definite state of mind or consciousness is called an *experience*. When we look around the room we get a distinct visual impression of the table and chairs and floor and walls and various objects about us. This composite experience is known as a *perception;* we perceive the world as presented to us by the visual receptors[2] and nerves. When we are ill at ease or in pain, the experience is of a very different sort: it is called a *feeling*. Our motor senses tell us how we move and how our body is placed; this type of experience has no familiar name, because it is popularly confused with volition. Psychologists call it a *conation*.

Perceptions, feelings, and conations are three fundamental sorts of experience. In each case the state of mind is made

[1] Besides these six mental processes there is another called *transformation* or mental chemistry. When several impressions combine together the result is often quite unlike any of the components, just as the properties of water are unlike those of the oxygen and hydrogen which compose it. Mental transformation depends on the *modification* of nerve impulses.

[2] Sounds are perceived through the auditory receptors. All the external senses yield perceptions.

up largely of sensations from one of the three great groups of senses. Perceptions are composed chiefly of external sensations; feelings, of systemic sensations; conations, of motor sensations. There is another fundamental kind of experience called *imagery*, which is made up largely of memories and other ideas. Memories are revivals of past sensations. They are not directly due to present stimuli. When you remember the scene at your last Thanksgiving dinner, the experience is not a visual impression. The memory is aroused by *some* sensory stimulus, but you do not at this present moment see the table and cooked turkey and mince pie which gave you the original experience.[1]

Besides these four fundamental types there are several important secondary kinds of experiences which are composed of elements from two or more different sources. For instance, an emotion is composed of sensations coming from *both* the systemic and motor senses. When we are very angry we have very intense organic sensations and very intense muscle sensations. The experience of anger is a combination of these two elements. The various fundamental and secondary experiences which occur in our mental life, and the elements of which they are composed, are shown

TABLE VI. — CLASSES OF EXPERIENCES

FUNDAMENTAL

Experience	*Dominating Component*
Perception	External Sensations
Imagery	External Ideas
Feeling	Systemic Sensations
Conation	Motor Sensations

SECONDARY

Experience	*Dominating Components*
Emotion	Systemic and Motor Sensations
Sentiment	Ideas and Systemic Sensations
Volition	Ideas and Motor Sensations
Thought and Language (Social)	Ideas and Motor Sensations
Ideals	Ideas; Systemic and Motor Sensations

[1] Memory is discussed in ch. viii.

in Table VI. We shall take them up one by one in the next few chapters.

One thing should be constantly borne in mind when we examine our experiences: our state of mind at any moment is rarely a pure experience of a single sort. When we look at the objects around us, our perceptions are always tinged with memory or feeling; the paper-weight looks heavy, the razor-blade looks painfully sharp. Our feelings are usually accompanied by some external impressions; and so on. But every experience is composed *largely* of a certain type of sensation (or ideas) or else largely of two types. A perception is an experience whose *prominent elements* are external sensations; and so of other experiences. In every case certain prominent ingredients fix the character of the experience state; they are its dominant components.

Subconscious Experience. — Many nerve impulses do not reach the higher centers in the brain and do not give conscious experiences. Yet these subconscious processes may be essential factors in our responses. When you are riding a bicycle you are not aware of the static sensations from the semicircular canals; but these sensations of balance are occurring all the time in the center for the static sense. They start a constant succession of motor impulses to the muscles of the arms and hands, which produce slight movements of the handle-bar to right or left; these movements keep you balanced and prevent the machine from falling over. How you *learn* to make these adjustive movements need not be discussed here.[1] The point is that you *do* make them without being conscious of the action.

Sometimes we are confronted with a difficult mathematical problem which we cannot solve. After puzzling over it for a long time we drop it and go about some other business. Then all of a sudden, without any apparent reason, the solution of the problem flashes before us when we are thinking of

[1] See ch. xi.

something entirely different. The problem seems to have been worked out subconsciously.

A clock strikes when you are reading and you do not notice it. A minute or two later you recall that it struck four times.

You meet a man — a perfect stranger — in some gathering, and at once take a dislike to him. You cannot explain this dislike for a long time. Finally you realize that he reminds you strongly of some one you know, whose personality is distasteful to you.

You go out for a walk and take a certain path because of the interesting scenery it offers. That is, you believe this to be the reason for your choice. You return disappointed, and suddenly become aware that you subconsciously expected to encounter a certain attractive damsel on the way.

Sometimes immediately after waking in the morning I can think of nothing but annoying blunders made by members of the family or others — perhaps months ago. This fault-finding attitude is due to subconscious systemic sensations of indigestion, not to anything in the external situation. On first waking, the digestive conditions overweigh the objective facts, and unwittingly control my thoughts, till I realize the reason and see the absurdity of this attitude.

Instances of subconscious factors in mental life might be multiplied indefinitely. Reasoning, memory, emotion, motor coördination — all proceed at times subconsciously. Often these subconscious attitudes or processes are valuable adjuncts to our conscious processes, as in the first example given. In other cases they interfere with the normal operation of our mental life. This is particularly true of unpleasant experiences or thoughts which we are ashamed of and wish to ignore. We try to forget them, and we succeed so far as our personal consciousness is concerned. But their traces may persist in the subconscious framework of our being. They crop out in unexpected and annoying ways;

sometimes they are betrayed by slips of the tongue, disquieting dreams, or inexplicable actions.

Psychoanalysis. — Attention has recently been called to this subconscious phase of mental life by the investigations of Sigmund Freud and others who have followed his method of investigation. These observers find that if you let your thoughts proceed naturally, without repression or guidance, frequently you will bring into the field of consciousness some subconscious memories or tendencies of whose existence you were not aware.

A certain man has an unconquerable repugnance to the contact of fur. He is unable to explain it. Under expert handling, a train of thought is started, beginning with the idea of fur. He is led through quite a succession of memories, and finally recalls an incident of early childhood, long forgotten, of being attacked by a shaggy dog.

This method of bringing the subconscious into the foreground is called *psychoanalysis*. It has been used with good effect by physicians to enable patients to conquer unreasoning fears and obsessions. Psychoanalysis is based on sound psychological principles; for our mental life depends largely on subconscious memory traces and on the attitudes which they have developed. It is also a fact that when we discover the real origin of a baseless fear we can often overcome it.

We must be cautious, however, in interpreting the results obtained by this method. There is danger of carrying our conclusions too far, as the followers of Freud have done repeatedly. Three great faults are found in the books which treat of subconscious life from this standpoint:

(1) They convey the idea that the subconscious part of our being is a very *highly organized personality*. Freudians speak as if there were a subconscious person (the 'censor') inside us, who forces us to repress certain thoughts and desires. As a matter of fact, the subconscious part of our personality

is not nearly so well organized as the conscious. It is rather a lot of independent, partly organized attitudes and tendencies, which enter separately into our life. The 'fear of fur' is one such tendency; the desire to meet a certain attractive girl is an entirely separate tendency. Each of these subconscious motives works independently, not through a general 'subconscious self.'

(2) There is danger also of *forcing the interpretation.* Some writers become so fascinated with the notion of subconsciousness that they use it to explain everything. A lady says to her physician, "Please do not give me big bills" — meaning 'big pills.' Immediately it is assumed that she was thinking subconsciously of his high charges. It is more likely that the letter 'b' in 'big' was carried over to the next word and *happened* to make sense. Had she said 'pig pills' or 'pig bills' the purely vocal nature of the blunder would have been obvious.

We must be especially careful not to attach importance to the *symbolic* interpretation which psychoanalysts assign to dreams and trains of thought. They are usually far-fetched or fanciful. In interpreting dreams they say that the sun stands symbolically for the dreamer's father; a woman dreamed of is symbolic of his mother or wife. A number symbolism has been worked out which is as fantastic as that of the fortune-tellers.

(3) Writers on the subconscious assign too much *sexual significance* to the hidden motives of action. The generative processes undoubtedly play a large part in human life — far more than we usually recognize. Civilized man has been taught to repress his sexual feelings, and the result is to magnify their importance in our silent thinking. But there are other important factors in our subconscious life. Nutrition is a powerful motive. The nutritive function dates back to the very dawn of life — long before there were two sexes. Avoidance of pain and the urge toward general activity are

also important motives of conduct. In studying mental life we should not be prudish and ignore the sex factor; on the other hand we must not be carried away by the zeal of uniform interpretation so far as to attribute every subconscious motive to this one source.

These cautions are needed to-day because the method of psychoanalysis has recently received considerable attention and has been exaggerated and distorted. The method itself is perfectly correct. By its use we can often arrive at a knowledge of many factors in our subconscious life which without it remain hidden: motives become clear which are otherwise incomprehensible. The danger lies merely in interpreting the results unscientifically. If the above cautions are observed there is little danger of misusing psychoanalysis.[1]

Varieties of Subconsciousness. — The term *subconscious experiences* may be applied to several different sorts of events in mental life. These fall into two classes: *Subliminal* consciousness and *subordinate* consciousness.

(1) SUBLIMINAL EXPERIENCES: These are due to stimuli which are so faint that the result falls below the threshold or limit of consciousness; there is no conscious impression at all. Or two stimuli may differ so slightly that we do not consciously discriminate between them.

A laboratory experiment illustrates this. The Jastrow cylinders are hollow cylinders of hard rubber with removable ends, which can be readily grasped and lifted. [Fig. 51.] In this experiment we take two of them and put weights inside so that one is slightly heavier than the other, say 150 and 153 grams. If you lift first one, then the other, they seem *about* the same weight.

[1] An amusing satire on the method is contained in one of the Provincetown Plays called 'Suppressed Desires.' One character dreams of a *hen stepping* about; the interpreter declares she was subconsciously thinking of a certain man named Stephen.

Now let the subject close his eyes and let the experimenter give him one cylinder after the other to lift and compare; let him judge (or guess) which is the heavier. Repeat this a large number of times, giving him the two cylinders now in one order, now in the other. If the subject were merely guessing, half of his answers would be right and half wrong. But it is found that in the long run the subject will give decidedly more than fifty per cent of right answers, even though he may believe he is only guessing. In other words, the slight difference between the two stimuli, even though it is so small as not to be consciously noticed, *has a real effect on our experiences.* It influences our judgments to the extent which the percentage indicates.

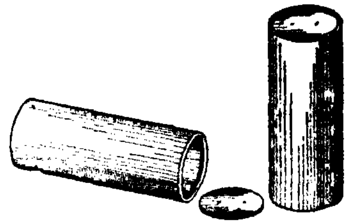

FIG. 51. — JASTROW CYLINDERS

Used to test the ability to discriminate small differences in weight, by lifting or by pressure on the skin. Shot is poured into each cylinder till the desired weight is obtained. When the ends are screwed on, the cylinders look and feel alike.

Similar experiments may be made with pairs of lines that are nearly equal, or with other pairs of slightly different stimuli. The results indicate the presence of *subliminal* elements in our experiences.

Somewhat the same sort of elements occur in the 'marginal' portions of our ordinary experiences. When you look attentively at any object the things at the far end of the visual field are hazy and almost unnoticed. They may not be quite subliminal, yet they do not enter into the general picture as conscious factors. Or again, if you are reading, the conversation and other noises about you are marginal. In such cases the second stimulus is not necessarily very faint, but the nerve impulses which it starts do not penetrate to the higher centers except in a faint degree. Their passage is hindered by fatigue of the synapses, which is equivalent to 'inattention.' Consequently the resulting sensations in the higher, conscious centers are marginal.

(2) SUBORDINATE LEVELS OF EXPERIENCE: Here the sensory impulse does not connect up with our present personal experience at all. Its effects are inhibited at the lower center. The case of the clock striking without your noticing it illustrates this; the original experience did not form part of your *personal* field of consciousness, but it did belong to a *subordinate* field of consciousness, as shown by the fact that you recalled it afterwards.

In other cases the experience never gets to our personal consciousness, and we are inclined to doubt whether the effect is not purely 'physiological' and unconscious. Some morning when I am in my laboratory it begins to rain. I wonder whether I closed my bedroom window before leaving the house. Hard as I try, I cannot recall closing it. On returning to the house I find the window closed. I *did* close it, for no one else has been in the room. Did I close the window consciously or not?

We may treat all such dissociated experiences as '*sub*-conscious'; that is, they are of the same sort as our conscious experiences, except that they are not part of our *personal* conscious life; they are experiences of our lower centers — not of the cortically organized self. It is helpful to regard even pure reflexes, such as winking, as subconscious. This view enables us to bring all experiences and all mental life into one general notion.[1]

Hyperesthesia and Anesthesia. — Stimuli sometimes have a more intensive effect than usual. This is called *hyperesthesia.* When we are in a high-strung nervous state we can hear faint sounds which ordinarily would not be detected; the sense of hearing is 'hyperesthetic.' Visual hyperesthesia occurs frequently. A hypnotized person is able to distinguish between blank sheets of paper, which look alike to the ordi-

[1] In many text-books the reflexes and instincts are treated as purely physiological activity and are not regarded as mental acts. This view is admissible, but it limits the field of psychology unduly.

nary eye. Tell him that one sheet is a photograph of X, another a picture of Y, a third of Z, and he will pick them out correctly after they have been shuffled. This abnormal discrimination is due to hyperesthesia: the hypnotic subject is unusually sensitive to differences of texture in the blank sheets. Certain persons can distinguish odors much better than others. They are hyperesthetic in the sense of smell as compared with the average man. When we are more sensitive to touch or cold in some special locality of the skin than elsewhere, it is called *local hyperesthesia.* A high-strung person is apt to have hyperesthesia of all the senses — that is, *general hyperesthesia.* Both local and general hyperesthesia may be induced by stimulants.

The opposite of this condition is *undersensitivity* or *hypesthesia.* It occurs especially in fatigue. When the air is laden with perfume in the blossom season we notice at first the overpowering odor; gradually the odor becomes less vivid and at length it may appear very faint indeed. In eating a sweet dessert we find that the sweet taste becomes gradually less noticeable. The same is true of other senses. These are instances of temporary undersensitivity of the receptor. In the same way the nerves may be temporarily impaired by fatigue of the synapses.

The limiting case of undersensitivity is *anesthesia,* where there is no sensation whatever. This occurs when a sensory nerve is cut or a receptor destroyed. Anesthesia may also be brought about by the action of certain drugs on the receptors. Cocaine applied to the skin deadens the pain sense temporarily. We have practical demonstrations of this in the dentist's chair. This condition is local anesthesia. The numbness of the arm when we lie on it in bed is not a sensation but the absence of usual sensations; it is local tactile anesthesia. Narcotic drugs, which act upon the nerves directly, produce general undersensitivity and sometimes general anesthesia. There is general anesthesia in dreamless sleep.

Hyperesthesia, normal sensitivity, undersensitivity, and anesthesia really form a continuous series containing all the various grades of sensitivity. Our degree of consciousness and the tone of our experiences depend very largely on the general condition and chemical changes of our body. Ill-health, bad nourishment, drugs, impure air, result in unfavorable physiological conditions of the bodily organs and unhealthy chemical products in the tissues. These harmful influences affect the nervous system and impair its activities, so that the entire aspect of the world may appear changed.

Relation of Sensitivity to Consciousness. — The intensity and vividness of our experiences depend on the nervous processes in the brain centers. These brain processes are determined by two separate factors: the activity of the *receptors* and sensory nerves, and the conditions of the *brain* itself.

Suppose some one knocks on your door. In order to hear the sound as the average person hears it, your ear and auditory nerve must be in normal condition. You may be deaf or hard of hearing; or you may have an unusually keen ear or be keyed up. The way you hear the sound depends on the condition of the ear and sensory nerves. The difference in sensitivity of the receptors is the basis of the series from *anesthesia* to *hyperesthesia.*

Now suppose your sense of hearing is normal and the auditory impression reaches the center. Ordinarily you hear the sound and say " Come in." But you may be busy reading and not notice the sound. Or you may be drowsy or asleep. If you hear the knocking plainly, you are *conscious.* If you are inattentive, the experience is *marginal.* If the knocking is loud and you do not hear it at the time, its effect is *subconscious* — it is an experience of your lower centers. If the sound is very faint, the effect may be *subliminal.* That is, your experience of the knocking depends not only on your receptors but on the condition of your brain. This is the

basis of the difference between vivid consciousness, marginal consciousness, and subconsciousness.

Summary. — In the two preceding chapters we examined the process of receiving information (sensation) and the nature of the sensations in man. This chapter takes up the question: "What happens when the sensory material reaches the brain centers?"

One important result is that *we receive the information.* That is, the man in whose brain the nerve impulses are going on is conscious and has sensations and various experiences. *Consciousness* means that the man is alive to his surroundings.

Still more important is the fact that the sensations do not remain detached and unrelated. They are *put together into definite experiences.* The piecemeal sensations are worked into shape by a number of mental processes: impression, suggestion, revival, attention, composition, and discrimination. As a result of this working over we have a number of different sorts of experience — perception, memory, etc. — which will be discussed in the following chapters.

In addition to our conscious or personal experiences there are certain brain effects of which we are not aware. These are called *subconscious* experiences. They are either (1) *subliminal*, that is, too faint to be noticed; or (2) *subordinate*, that is, they occur on a lower brain level and not in the cortex. Our conscious experiences are also subject to changes of vividness due to the condition of our receptors: *hyperesthesia* means a high degree of consciousness; *undersensitivity* (hypesthesia) means a faint degree of experience, the limit being *anesthesia*, or entire absence of sensation.

With practice we can learn to observe our own experiences and note their characteristics. This method of studying mental facts is called *self-observation* or introspection.

PRACTICAL EXERCISES:

28. Examine your experience in trying to read when an interesting conversation is going on in the room. Describe the changes of attention from one group of impressions to the other, and the marginal elements of the experience.
29. Report your experiences in trying to listen to a lecture when you are very sleepy. Note especially any fluctuations of attention, diffusion of attention, snatches of anesthesia.
30. Describe some recent experience in which you have worked out a problem subconsciously or performed some rather complex act subconsciously.
31. Describe any notable experience of anesthesia or hyperesthesia in your recent life.
32. Examine one of your well-formed habits (e.g., dressing, eating with table implements, taking a customary walk); what factors seem to be (1) conscious, (2) subconscious, (3) absolutely unconscious?

REFERENCES:

On attention: W. B. Pillsbury, *Attention*.

On subconsciousness: M. Prince, *The Unconscious*.

On psychoanalysis: S. Freud, *Psychopathology of Everyday Life*.

CHAPTER VII

PERCEPTION

Nature of Perception. — Perceptions are experiences due to direct impressions from the *external* senses. This is slightly narrower than the ordinary use of the term. It is all right in offhand conversation to speak of 'perceiving a pain' or 'perceiving the truth.' But when we study mental states systematically, it is important to call different sorts of experiences by different names: We *perceive* what is outside the body, we *feel* what takes place within the body, and we *believe* the truth of propositions.

Perception is the grouping together of various external sensations[1] into a single, united experience. Your perception of this book involves putting together a large number of sensations obtained through your eye and optic nerve. Each letter on the page stimulates your retina at some point and starts a nerve impulse along some of the optic nerve fibers toward your brain. Hundreds of these impulses reach the visual center at the same time and give separate sensations. In the center the separate impulses are brought together by the nervous process of collection, and the complex impulse which ensues arouses a complex experience of the whole printed page. The combining process is called *perception;* the experience is *a perception.*

Our perceptions correspond very closely to the objects which cause them. If your eyesight is good, the shape and markings of the perceived book are very similar to the shape and markings of the real book which lies beyond your eyes

[1] An 'external sensation' is a sensation coming from one of the 'external senses,' such as sight (see Table I, p. 58). The stimulus is outside our body. The expression *external sensation* is short for *externally stimulated sensation.*

and furnishes the visual stimuli. This is true also of perception by touch. We perceive the roughness of sandpaper or of a gravel walk. Our experiences resemble the situation in the world outside our body.

The correspondence between perception and reality is not always perfect. We often have *illusions* in perception, — that is, things do not always appear as they really are. Some of these illusions are very striking. In Fig. 52 we see perfectly clearly the entire outline of the letters; we see lines where there are no lines at all.

FIG. 52. — FILLED-IN PERCEPTION

Hold the book at a distance and the outline of the letters appears complete. The missing lines are supplied in perception.

The lack of complete harmony between the perception and the thing perceived is not remarkable when we consider the chain of processes involved — light waves, retinal activity, nerve impulses, central collection, and other operations. It is like transmitting a telegram. You write out the message in pencil, the telegrapher clicks it off, the receiving operator hears a succession of dots and dashes and typewrites the words in Roman letters. It is really surprising that more mistakes do not occur in perception. The exactness with which our experiences correspond to reality is evidence of the high precision of our receptors and nervous system.

Often our perceptions are *more* like the real object than the sensations which compose the experience would lead us to expect. For instance, if we tilt a book at an angle (like the book shown in Fig. 56 [1]) the four corners still appear as rectangles, though the sensations taken by themselves would make the page look diamond-shaped. The reason why the corners look rectangular is that our perceptions include not merely sensations but *memories* of other books we have seen

[1] P. 151.

and handled in the past. These memory elements combine with the present sensations, and since all books are made with square corners the resulting perception takes that form. This tendency to interpret according to past experience is so strong that in Fig. 53 the rectangular cross-lines look tilted, and the tilted lines look rectangular.

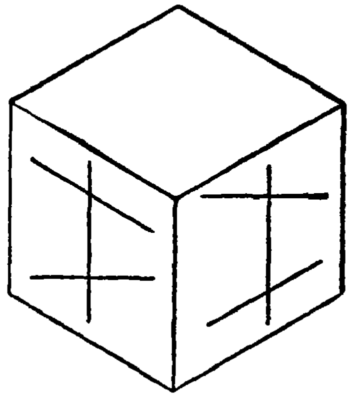

FIG. 53. — ILLUSION OF THE CROSSES

The rectangular cross-lines either look oblique or seem to swing into the paper; the oblique cross-lines look rectangular.

There are certain errors in perception due to defects of the receptors. If you are astigmatic, everything looks somewhat distorted; if you are nearsighted, objects at a distance are blurred. You are quite aware in such cases that your perception is faulty. But there are also errors in perception which one does not appreciate. Certain objects are colored with ultra-violet or infra-red light; we cannot see these colors because the retina does not receive such rays. Ordinarily we see nothing of what is going on inside our own body; but the X-ray penetrates the tissues, and if our eyes were sensitive to the X-ray, we could see through a human body almost as readily as through a glass window. There are sounds in the world about us which perhaps an insect can perceive plainly, but which man cannot hear. The dog's perception of his master by smell is incomprehensible to the human nose. We do not perceive the earth's magnetic current directly at all.

It follows that our perceptions of the world about us are not exactly like the real world. We are limited to material that our receptors can take in. So far as we *can* perceive, we generally perceive things in their real relations; we interpret our sensations truly, except for certain illusions based on

habit. The piecing together and interpretation of sensations is due to the mental processes of composition, attention, etc. (ch. vi). It takes place *after* the nerve impulses have reached the brain centers.

There are quite a number of different ways of working over the sensory material in perception. We shall discuss them in the following order:

Discrimination
Perception of surfaces
Perception of depth
Perception of objects
Perception of time and events

a. Discrimination; Weber's Law. — Discrimination of two things does not always mean that we consciously perceive their difference. A very small difference between two sensations may lead to *subconscious* discrimination. When we compare two lifted cylinders that are nearly equal in weight there is some discrimination, as shown by the fact that considerably more than half our judgments are correct, though they seem mere guesses.[1] Our automatic balancing movements when we ride a bicycle are based on subconscious discrimination.

Conscious discrimination occurs when the nerve impulses reach the higher brain centers in the cortex. We perceive a difference of quality or intensity between two sensations when the two sensory impulses are brought together in a perception center of the brain, and the central impulse is distributed on the basis of this difference. Suppose you lift two cylinders which are noticeably different in weight. The two sensations are different, and this difference starts a motor impulse in the proper channel, so that you point to the heavier, or say, "the first is heavier," or respond in some other discriminative way. You react discriminatively because you have arranged to do so beforehand, and because

[1] See ch. vi, p. 137.

the motor paths from the brain centers are prepared to send the impulses down to the motor organs. But whether you will point to the first or to the second cylinder is determined by the difference between the two sensations and by the central process of discrimination.

Considerable work has been done in the psychological laboratory on the perception of very small differences. There is no special problem in distinguishing large differences: when a thick cloud passes over the sun, we notice the darkening effect at once. But if we are reading in the late afternoon it often happens that we do not notice the growing dusk till suddenly the strain of reading brings us to a realization that the light has greatly diminished.

How much difference must there be between two things in order that we may be able to consciously distinguish them? This is an important problem in psychology, since it determines the number of different impressions we are capable of experiencing. In the laboratory this is investigated by taking two stimuli of the same sort and varying the intensity of one (the other remaining constant) till we *no longer observe* any difference between the two. Or, starting with the two alike, we gradually vary the intensity of one till it is *just observably different* from the other. This can readily be done with any of the external senses; we can compare the brightness of two lights, the loudness of noises, the intensity of tastes and odors, the heaviness of pressure or lifting.[1]

Experimental investigations show that the intensity of a stimulus must be *increased by a certain proportion of itself* in order to give a just observably different sensation. For example, whatever the intensity of a light, it must be increased by 1/100 of itself to appear brighter; pressure on the skin (without lifting) must be increased by 1/20 to be distinguished; a lifted weight must be 1/40 heavier in order to be noticeably heavier. This law of discrimination was first

[1] The muscle sense belongs among the external senses in this respect.

formulated by E. H. Weber in 1834, on the basis of his own experiments, and is called *Weber's Law.* Weber's Law may be stated in a simple form: *Sensations increase in arithmetical progression as the stimuli increase in geometrical progression.*

Weber's Law as applied to *sound intensity* is represented by the curve shown in Fig. 54. Here the fraction of increase is 1/3. For pressure and brightness the curve is of the same form, but it is much flatter: each step requires *less* increase in these senses than in hearing.

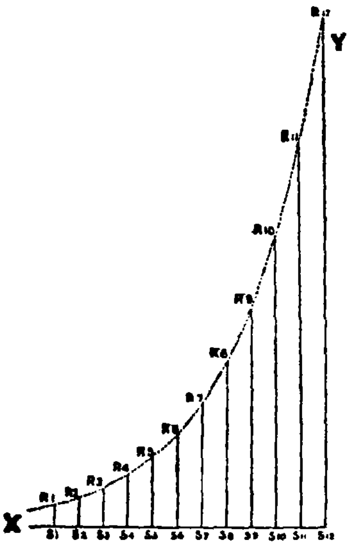

FIG. 54. — CURVE OF WEBER'S LAW

Form of the curve for intensity of sound; the Weber fraction is 1/3. Just observable increases of sensation are indicated by equal distances along the X axis at points S_1, S_2, S_3, etc. Corresponding values of stimuli are represented by the lines $S_1 - R_1$, $S_2 - R_2$, etc. For pressure the Weber fraction is 1/20; the curve is much flatter.

When two stimuli are nearly alike our discrimination is often influenced by inattention, distracting stimuli, and other factors; so that a large number of experiments are needed to determine the fraction of increase exactly. But the fundamental principle can easily be verified. Compare the difference of brightness in a darkroom lighted first with one candle, then with two; now compare daylight, with daylight increased by one candle. In the darkroom comparison the difference appears very great, in the daylight it is not noticeable. The difference between 3 oz. and 4 oz. is very noticeable, while the difference between 4 lb. and 4 lb. 1 oz. is imperceptible. It is always the *relative* difference — not the *absolute* difference — that we distinguish.

The fraction of least observable difference is called the *Weber Constant.* The constant for various senses is shown

in Table VII. Weber's Law holds to some extent for discrimination of duration and size as well as intensity. It does not hold for least observable differences in qualities, such as color hues and auditory tones.

TABLE VII.— VALUES OF THE WEBER CONSTANT

Sensation	*L.P.D. Intensity*	*Individual range*
Visual (light)	0.01	0.015 to 0.005
Auditory (noise)	0.33⅓	
" (tones)	0.15	0.20 to 0.125
Olfactory	0.25	0.33 to 0.25
Gustatory	0.25	0.33 to 0.25
Tactile	0.05	0.10 to 0.033
Warmth	0.036	
Cold	0.036	
Kinesthetic	0.025	0.05 to 0.013

Each fraction denotes the *proportion of the original stimulus* which must be *added to it* in order that the sensation may be just noticeably greater.

b. Perception of Surfaces. — The perception of *space* relations includes two very different processes. One is perception of the *size and shape* of objects that we see or touch. The other is the perception of *distance* of objects from our body. The former is called *surface* perception, the other is *depth* perception.

Surface perception is much the simpler process. Objects which we see, stimulate a great number of rods and cones in the retina, and the things which touch our skin stimulate many different touch receptors. When the separate visual (or tactile) impressions from all parts of the object are combined together in the brain centers we get a perception of something spread out before us. The question is, how we come to perceive the various parts of any object *in the same relations* to one another that they really bear. This really involves three distinct problems. Take, for instance, touch perception [Fig. 55]:

(1) How do we *distinguish* two points A and B on the skin at all? Why do they not fuse, like sounds?
(2) How do we perceive that a given point A on the skin is *farther* distant from C than from B?
(3) How do we perceive that C and X are in *different directions* from A?

The same three questions come up in visual perception: How do we *distinguish* different points, perceive their *distance apart*, and appreciate *direction?* Sight and touch are the two chief sources of surface perception.

(1) First as to *discrimination of different points.* This is due to slight differences in the receptors themselves. Each rod and cone in the retina, each touch corpuscle in the skin, is slightly different from every other and gives slightly different sensations. These slight differences are *local signs* (that is, indications of locality) which enable us to distinguish one point from another. We can think of them as the 'personal touch' which each receptor gives to its stimuli, just as the timbre of each man's voice has its own individuality, which enables us to recognize who it is that is talking regardless of what he is saying.

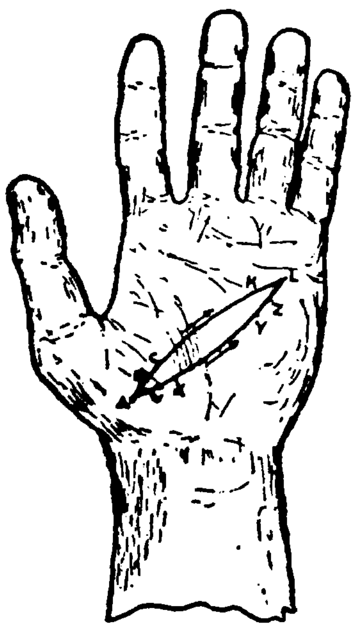

FIG. 55.—SPACE PERCEPTION IN TOUCH

Arrows indicate direction in which stimulus moves over the skin. (See discussion in text.)

(2) The second question is how we come to perceive correctly the size of objects and their *distance apart.* Two factors assist us in getting our clue to surface distances. (i) When objects move over the body or before the eye, or the skin or eye is moved over stationary

objects, any given point on the object stimulates a number of receptors *in regular order*. On the skin the points A B C . . . K L [Fig. 55] are stimulated in succession, or else some other series A W X Y Z L. We never get the sensations in a

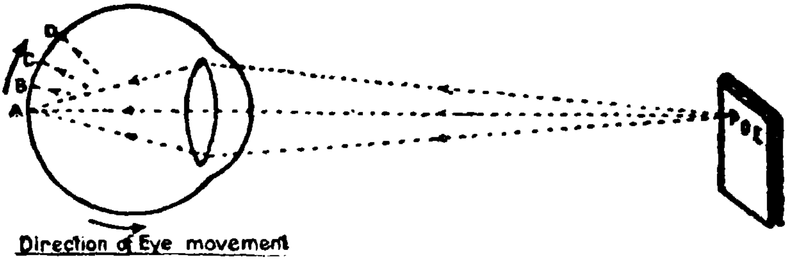

FIG. 56. — VISUAL SPACE PERCEPTION

Dotted lines show paths of light waves from a point P on the book-cover toward the eye, first spreading out, then brought together by the lens and focused at A on the retina. When the eye moves counter-clockwise (in direction of lower arrow), the picture of P on the retina moves clockwise (left-hand arrow) from A to B, C, D. (See discussion in text.)

random, jumbly order, A K B L C. The same is true in sight. The eye moves regularly; any given point (say, the letter P in Fig. 56) stimulates the rods and cones of the retina in some regular order, such as A B C D, never in random order.

This means that any given point K on the skin or D on the retina, which is situated far from the starting-point A, is not stimulated by a given object immediately after A, but only after a number of other points have been stimulated. The same series A B C K or A B C D occurs over and over again, and this enables us to appreciate that B and C are nearer A than are any of the points which are stimulated afterwards.

(ii) The muscle sense aids greatly in building up our perception of size. When we move the hand or the eye we get muscle sensations. If the movement is quick, the muscle sensations are more intense; the unusual muscular exertion informs us that the starting and stopping points are farther distant than the mere time would indicate. If the move-

ment is very slow, the muscle sensations are faint and the distance is perceived to be small.

Our perception of the length of a line or the size of an object, then, is due to these two factors: (i) the *orderly succession* of points on the skin or retina, with their distinguishing local signs, and (ii) the *intensity of the muscle sensations* which accompany the movements of our limbs or eyes.

(3) Finally the question arises, how we come to appreciate *difference in direction.* Muscle sensations furnish the chief information regarding the direction of lines and their curvature, which is an important element in surface perception. In Fig. 55 the points C and X are equally distant from A. But the hand moves differently in the two cases, so that the muscle sensations when we move from A to C are different from the muscle sensations which accompany a movement from A to X.

In sight this factor is even more evident. When we turn the eyes upward the superior muscles do most of the contracting; when we turn them toward the right it is one of the horizontal muscles of each eye. The muscle sensations in the two cases are different, and this difference of sensation enables us to distinguish the direction of the two movements readily. For diagonal movements one horizontal and one vertical muscle come into play; we perceive the direction according to the proportion of sensation from each muscle.

To sum up, surface perception includes three independent mental acts: (1) We distinguish between *different points* and parts of objects by means of *local signs.* (2) We perceive their *distance apart* by means of the *orderly succession* of local signs and by the varying *intensity* of the accompanying *muscle sensations.* (3) We appreciate differences of *direction* by means of the *different muscle sensations* which accompany movements of the eye, hand, or other members. When we look at things or touch them, we get these clues in addition to the touch and visual sensations. They give us information

which enables us to perceive objects as spread out in space before us.

c. Visual Depth (Projection and Perspective). — The distant senses give us information about things that are more or less distant from the body. The stimuli come in contact with the receptors, but the objects themselves do not. When we see and smell a rose, stimuli from the rose affect our visual and olfactory receptors; but the rose remains out there on the stalk, some distance off. In such cases we perceive the object " where it is " — the rose does not seem to be in contact with our eyes or inside our nostrils.

How is it that we see the rose projected out at a distance from the eye, although our sensations are due to stimuli on the retina? Perception of *depth* (that is, distance straight away from the eye toward the horizon) is not due to local signs; for the stimuli from all distances in the same line from the eye strike the same point on the retina and bear the same local sign. The same is true of hearing and smell.

Sight is far more developed in its space relations than the other senses. We are able to distinguish very accurately the distance of objects from the eye. We see a statue 'in perspective' — that is, the perception rounds out toward us in curves like the real statue. What factors in the sensation enable us to project our visual perceptions in this way?

Depth perception in sight is due to a combination of certain non-visual information with the visual sensations, just as surface perception is due to the combination of local signs and muscle sensations with the sensations of sight. Some of the clues for perceiving depth accompany the visual sensations from each eye separately; we get them as readily when one eye is closed. Other clues are due to the two eyes working together. There are six *uniocular*, and two *binocular* factors.

(1) Accommodation Sensations: The lens of the eye bulges out when we look at objects close by, and flattens when

we look at distant objects.[1] Muscle sensations accompany these changes of the accommodation muscle; the sensations vary with the amount of muscular contraction. These *accommodation sensations* are an important clue for perception of depth or distance away from the eye. When we focus the eye for a given distance we get a certain muscle sensation which tells us how far off we are focusing.

Accommodation sensations assist us only in determining a limited range of depth distances. The lens of the normal human eye is completely relaxed when we focus for about 6 to 10 meters (20 to 33 feet). There is also a near-by limit, normally about 10 cm. (4 inches); we cannot squeeze the lens sufficiently to get a clear picture of nearer objects. Within these limits the changes of accommodation sensations furnish clues which enable us to perceive rather exactly the depth of objects. For perception of greater distances other factors are needed.

(2) DISTINCTNESS: Owing to the dust in the atmosphere, objects at a distance are not so distinct as those near by. Objects seem close to us if their *outlines are sharp* and their details are clearly marked off; they appear farther off as the outlines and details grow more vague. Distinctness is an important clue for depth perception, but it often gives misleading information. We misinterpret distances when the atmosphere is unusually clear or unusually dense. In Colorado mountains thirty or forty miles away seem only a half-hour walk. On a misty day objects look larger and farther away than they really are. These mistakes of perception are called *illusions*.

(3) SHADING: When light strikes the human face from the right, the nose casts a shadow on the left cheek, the mouth is in shadow, etc. *Shading* is a clue to the different distance of various parts of an object from the observer. This factor

[1] Stand close to some one, at his side, and observe the changes as he looks near by and far away.

gives the finest of all depth distinctions. It enables us to see objects *in perspective* and *in relief*. So powerful is its influence that we tend to interpret the flat surface of a painting or photograph in terms of depth. Some objects in the picture stand out and others recede back from the canvas or paper. In the theater, we perceive a cottage in the background at least two or three miles away, though we know perfectly well that it is really painted on a stage curtain. The illusion is irresistible if the curtain is seen through a glass window; the glass makes the imperfections of the painted curtain less apparent.

(4) SUPERPOSITION: If two objects lie in the same straight line, the nearer one will hide part of the farther one. When we see the outline of a house broken by a tree, the house looks farther away than the tree. This effect, called *superposition*, is of great use in perceiving the relative distance of different objects from us. The illusion of perspective in photographs and paintings depends largely on this factor.

(5) SIZE AND SHAPE OF FAMILIAR OBJECTS: Many of the familiar creatures and objects around us are of a 'standard size,' with only slight variations. Grown-up human beings vary in height only a few inches from the average. When we see a man, *the size of the impression* on our retina is a clue to his distance. If the retinal picture is small the man looks far away, if it is large he looks near by. Houses differ considerably in size, but the windows and the height of the stories are fairly uniform; we appreciate the distance of a house by means of this factor. And so of any familiar thing.

This factor may give rise to illusions. A miniature house on the stage is perceived as a full-sized house in the distance.

The *shape* of a familiar object also gives us a clue to its position. Book covers are usually rectangular; when we see a book lying before us whose cover has two acute and two obtuse angles we project one of the acute corners farther

away from us than the other. [Fig. 56.] In paintings and pictures the perspective effect is enhanced by this factor.

(6) RELATIVE MOTION: When we look out of the window of a moving train, objects near at hand pass by much more rapidly than distant objects. If we are standing still and move the head to right and left the same thing happens. In either case we get a clue of the distance of various objects from their *relative rate of motion* across the field of vision. For one-eyed persons this is the most important factor in giving perspective to the landscape.

(7) CONVERGENCE: Focusing the two eyes upon a single point is called *convergence*. When we look first at an object some distance off and then at a nearer object in the same direction, the eyes do not turn both together, as in ordinary

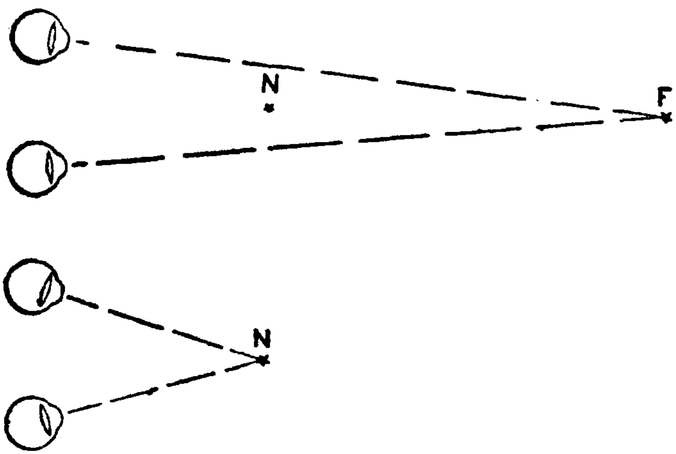

FIG. 57. — CONVERGENCE OF THE EYES

When the eyes are fixed on a distant point F both pupils are slightly *converged* toward the nose, as shown in the upper figure. When we look from F to a point N near by in the same direction, both eyes turn in toward the nose (converge more), as shown in the lower figure.

movements. Either one eye remains fixed and the other turns slightly inward (toward the nose); or else both turn inward — they converge. [Fig. 57.] Since the eye movements in convergence are different from ordinary eye move-

ments, the accompanying muscle sensations are different. They give us a clue as to the distance from us of the point upon which the eyes are converged. This factor supplements the various uniocular indications described above; but its value is limited to distances of not more than one hundred feet; beyond this there is practically no change in the angle of convergence.

(8) BINOCULAR DIFFERENCES: If you hold a piece of cardboard between the two eyes with one edge toward you, the left eye sees only one side of the cardboard while the right eye sees the other; your two visual fields are different. If you hold a ball near the eyes, the right eye sees a little farther around it to the right than the left eye. Any rounded object which is near your body presents a slightly different picture to the two eyes. These two different pictures do not clash as one would think; they combine into a single definite perception, so that the object 'stands out in relief.' It looks rounded out and solid.

The combination of binocular pictures may be studied by means of the stereoscope. [Fig. 58.] In the holder of the stereoscope, several inches from the eyes, is placed a card with two pictures. The pictures are nearly alike, but not quite; the left picture is the way a solid object or scene would look to the left eye if it were some distance off — the right is the scene as it would appear to the right eye. By means of prism lenses the two pictures are brought together in the middle of the field of vision. One is seen by the right eye and the other by the left, but we see only a single picture. Examine a pair of stereoscopic photographs without the instrument and notice how different some of the details are. Yet when the two are combined in a stereoscope they give one distinct picture, just as we would see a similar scene with the two eyes in real life.

How these Clues are Used. — Of the various sorts of clues that enable us to see at a distance, only one (binocular differ-

ence) is really a visual sensation. Some of the clues are muscle sensations that occur at the same time as the visual sensations and combine with them; and some are not even sensations, — they are *memories of past sensations*. The size

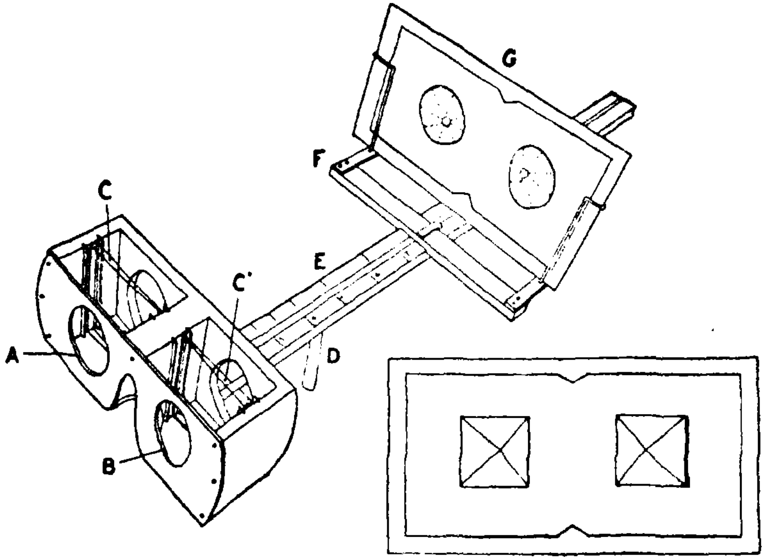

FIG. 58. — STEREOSCOPE

Above, a stereoscope. Left eye looks through A at left-hand picture of card G in card holder F; right eye looks through B at right-hand picture. Prisms C, C' bring the two pictures together into a single view in the middle of the visual field. E = rod for sliding the holder to and from the eyes. D = handle to hold stereoscope.

Below, a card with pair of stereoscopic pictures. Looking at the card through the stereoscope we see a single picture of a pyramid. (The two pictures in the upper card G also combine into a solid-looking picture.)

of familiar objects is a memory of many former perceptions of these objects. When *we perceive a tilted book as having* right-angled corners, the experience involves previous perceptions of books in many tilted positions. The memory clues and muscle-sense clues are combined with the visual sensations derived from the objects and the total effect is a perception of things at a distance. The scene is *projected.*

It would be wrong to say that we first see things flat and

then correct this impression. The projective process is immediate — it is not an inference. We perceive the size and tilt and depth of things *at once.* This is proved by experiments with instantaneous or very short exposures.[1]

It is difficult to understand how we come to have *one single* perception, and not two, when each of the eyes has a retinal picture of the entire field. This is partly explained by the course of the optic nerve. At the optic chiasm [Fig. 27[2]] the fibers from the *inner* (nasal) half of each retina cross to the opposite side of the brain; those from the outer half do not. The fibers from the left half of each retina go to the left side of the brain, those from the right half go to the right side; so that two similar stimuli from corresponding points in the two retinas arrive at *neighboring points* in the visual center of the brain at the same time. Just how these pairs of corresponding central points are connected is not known. It is a case of fusion, and is similar to the fusion of identical sound impressions from the two ears.

It is also puzzling to understand how we see objects " off at a distance " when the perception process actually takes place in the brain. This much can be said about it: Projection is one of many ways in which the raw material of experience is worked over and transformed. A ' projected out ' quality is added to the various sensations that enter into our experience of distant objects, just as a ' spread-out ' quality is added to the experience of visual surface. Our projection of visual experiences means only that we project most of these visual pictures *beyond the visual picture of our own body*, which forms part of our visual world.

Projection in Other Senses. — Depth perception and projection occur to a considerable extent in smell and hearing. Odors are perceived not in our nostrils but in the rose or

[1] Accommodation and convergence require time; these factors would not occur in instantaneous exposures.

[2] P. 66.

other outside object which is the real source of the stimulus. Sounds are localized outside the head, often at a considerable distance.

The actual distance of odorous objects or sounds is not perceived so precisely as in sight. If we possess the sense of sight we usually project odors into the objects that we see and measure the distance of the source visually. The projection of sounds is assisted by training. Certain sounds are ordinarily limited to a certain range of intensity. If they are softer or louder than usual, we localize them far off or near by.

The cutaneous senses (warmth, cold, touch) furnish a few independent indications of depth and projection. If we hold our hands near a hot stove we locate the sensation of warmth outside the body toward the stove. Cold is similarly projected when we hold our hand near a cake of ice. Ordinarily our eyes are open and there is visual projection also. But even with closed eyes some temperature projection takes place. In touch, which is well developed for surface perception, there is only slight projection.

Projection in touch usually occurs when a rigid object connects the source of stimulation with our touch receptors. When we write with a pen we feel the point of the pen touching the paper. When we cut with scissors the touch sensation is projected to the place where the cutting occurs. When we walk we feel the soles of our shoes pressing on the ground, and in using a cane we feel the tip of the cane where it touches the pavement. Most singular of all, when we dig with a spade we feel the impact of the spade underground when it strikes a stone.[1]

All this indicates that we have a general tendency in perception to *project a sensation as far out from the body toward the source as the data warrant.* Even our systemic sensations are projected from the brain centers to their source in

[1] In these illustrations the word 'feel' means to 'have a perception.'

the receptors within the body; muscle sensations of effort are often projected into objects, so that we are apt to endow inanimate things (such as the wind) with muscular power and strength.

The space perception of the blind is quite different from that of normal men. Blind persons perceive lines and surfaces just as we do, except that they do not discriminate nearly so finely. But (1) they perceive *all sides of a solid at once* — the back as well as the front; and (2) they do not perceive objects *in perspective.*

A blind man perceives the shape of a ball by putting his hands around it; his perception includes every part of the spherical surface with equal vividness. To us, the farther side is hidden and does not enter into the perception except through memory images or touch, so that usually we perceive only half the ball at a time. And so of objects generally; the blind perceive them *all around* at the same time; ordinarily we do not. It is not easy for us to picture what this means, because our space perception is so largely visual. But if you close your eyes and examine objects by touch, you can appreciate the blind man's kind of perception somewhat better; when you handle a book or a ball you get as clear an impression of the far side as of the side nearest you.

On the other hand, a blind person has no idea how anyone can get perceptions of near and remote objects all at once. Accommodation, shading, convergence, mean nothing to him. To the blind, perception is largely an exploring process, which takes time.

d. Perception of Objects. — When a whole group of stimuli affect our receptors at once, some of the resulting sensations enter into the perception more clearly and vividly than others. Usually there is a 'focus of attention' comprising certain elements that are especially clear; other parts of the perception are fairly vivid, while others are indistinct or quite unnoticed. This unevenness in the perception is partly due to

differences in the intensity of the stimuli. A loud sound usually occupies the focus of attention, while very faint sounds which accompany it pass unnoticed. A bright-colored pattern stands out prominent, while the dimmer background is scarcely observed at all.

There are also differences of vividness in our perceptions which do not depend on the intensity of stimulation. When we look at a human face we do not observe each individual feature distinctly. Usually the eyes, nose, and mouth are most prominent, the ears and chin and the arrangement of hair are noticed somewhat, while the curves and shading of the cheeks may escape notice altogether. These differences are due to attention and inattention — that is, to the focusing of certain nerve impulses and inhibition of others at the brain centers, where sensations are combined into perceptions. The focusing process enables us to perceive objects as units. The human face is seen as ' a face,' not as a mass of separate features. In looking about the room you perceive a number of objects — chairs, tables, books, etc. — each one of which is focused as a distinct *thing*, with its individual features more or less merged in the total perception.

The visual perception of objects is strengthened by impressions from other senses. Usually objects about us stimulate several senses at once. An orange may affect the eyes, the skin, the muscles, the nostrils, and the taste receptors. We see, touch (or ' palp '), heft, smell, and taste the orange, all at the same time. The various sensations combine into one single perception — a perception of *the orange* with its many characteristics. This is *object perception* in its most developed form.

Even when some of the characteristic sensations are lacking we supply them through memory elements. In looking at an orange we get an impression of its taste and heaviness. An iron crowbar ' looks heavy '; an aluminium dish ' looks light.' All our perceptions of objects in adult life are tinged

with such memory elements, due to many past experiences.[1]

The practical importance of the non-visual elements in perception is greater than we are apt to realize. We only appreciate this when some of these elements are missing. In certain abnormal mental conditions the muscle sensations are cut off; the patient does not feel the resistance of objects that he lifts or pushes. Nothing seems to have weight. In such cases the patient declares that the things he sees do not 'look real.' The whole world about him seems an illusion, because his object perception is incomplete: the muscular sensation of resistance is absent.

The way in which *habit* influences our perception of things is brought out if we look at the landscape with the head upside down. The horizon seems much farther off; the sky coloring near the horizon is more vivid. In a wrong-side printing of a photograph the right-and-left reversal of buildings or animals does not look strange because we are accustomed to see buildings and animals turned either way. But if printed letters (especially handwriting) are reversed, they look very strange. The script in Fig. 76[2] is almost impossible to decipher unless you look at it in a mirror. This is because words are always written in a left-to-right direction — never from right to left. The reversal of white and black also plays havoc with perception — it makes a familiar face quite unrecognizable. [Fig. 59.]

A special problem in connection with object perception is the number of objects that can be perceived distinctly at once; not the total number of *details* noticed at one time (which may be indefinitely great), but the number of *vivid groups* which are marked off as separate objects. This is called the *span of attention*. Experimental investigations indicate that the span depends upon several factors. It is increased by voluntary

[1] In perceiving Fig. 52 (p. 144) certain visual memories are added.
[2] P. 290.

attention and diminished by fatigue. Under ordinary conditions from six to eight objects are clearly distinguished simultaneously. The number may be increased with practice to about fifteen.

FIG. 59. — WHO IS THIS?

Fix the white dot in the center steadily for 60 seconds. Then look away quickly to a white surface; a negative after-sensation will appear, and there should be no difficulty in recognizing the portrait. [From *The Farm Journal*.]

Objects and Space. — The space relations of our several senses coincide. We feel (palp) our hand in the same place as that in which we see it. The taste, touch, and warmth of the steak we are chewing are all localized in the mouth. Our field of perception consists of only *one space*, not of separate spaces for sight, touch, and other sensations. This is brought out strikingly when the normal relationship of the senses is disturbed. If you look at your hand through a reversing lens you feel the fingers in a different place from where you see them. In using a microscope you push the slide in one direction to move the visual field in the opposite direction.

The oldest recorded contribution to experimental psychology, Aristotle's experiment, illustrates this. Aristotle noted that if the middle fingers are crossed and a stick or marble is placed between them (the eyes being closed), the object appears double. This is because in ordinary experience the far sides of these two fingers lie some distance apart and are never touched by the same object.

Our integration of the clues from various senses into a perception of one general 'space' is the result of habit. This can readily be verified. When we become accustomed to using the microscope the direction of the slide's motion as we see it, tallies with our sensation of muscular pull. One

who wears near-sight glasses has no difficulty in touching objects in the exact place where he sees them, though when he first wore glasses everything appeared slightly displaced. That we can learn to combine properly our various space perceptions even under most exceptional conditions, is proved by Stratton's experiment.

Stratton wore a large reversing lens continuously for seven days, removing the apparatus only at night, when his eyes were kept bandaged. Seen through this lens the whole field of vision was turned completely around, like the picture on a camera plate. With respect to touch and muscle sense his left hand was seen at the right side, his feet were above his head, the lintel of a door was where the threshold ought to be. At the end of the week he found that the space relations were almost completely reintegrated to meet the new conditions. He reached for things where he saw them and manipulated implements properly. He felt his hands, feet, and body in the same place and in the same relations as their visual pictures. Only the position of the head, which had not been seen during the experiment, tended to remain in its old relations — its localization was confused and vacillating.

e. Perception of Time and Events. — Most stimuli persist for some time, and the sensations which they produce persist too. When you are looking at an object and it moves or disappears or changes, the nerve impulses in the brain centers do not immediately cease or alter all at once. There is usually a certain period during which the old perception is fading away and the new perception is beginning. In other words, successive perceptions dovetail together; we perceive at one and the same instant both the incoming and the outgoing events. The 'now' of perception is not the same as the physicist's idea of 'the present.' It is not a thin knife-edge separating the past from the future, but a fair-sized period of time. The *perceptual present*, as it is called,[1] may cover as much as

[1] It is also called the 'specious present.'

six seconds. All impressions within this period of time may be *present to you at once.* This is what makes it possible for you to perceive changes and events as well as stationary objects.

When you see a man running you get a series of visual sensations of his various positions. These successive sensations are all embraced in one perceptual moment, and they combine into a perception of *running.* Examine the instantaneous photographs of a man walking. No one of them is specially characteristic, and some look absurd. Your perception of walking is an integration of the whole series; the absurd positions are not noticed. The pictures of a man jumping or of a horse galloping show this even more strikingly. You have a very definite visual perception of the act as an event, though every one of the instantaneous poses looks unreal and ridiculous. The same is true of other common actions. Many activities of inanimate nature are perceived as events rather than as a succession of situations; the lashing of surf on the beach, the fall of a leaf, the flapping of a sail, and the waving of a tree in the wind are perceived as 'happenings.'

In the sense of hearing, successive sounds tend to combine into definite groups, particularly in music. A tune is composed of a series of groups, each consisting usually of 3 or 4 successive tones. One tone in each group is accentuated in some way: the accented tone may be *louder* than the others, or it may be slightly *prolonged,* or the effect may be due to an *accompanying pattern* (dum-da-da-dum-da-da) in the bass. This grouping of sounds by accentuation is called *rhythm.* Rhythm occurs in poetry as well as in music. Even when there is nothing in the stimuli to cause it, we tend to perceive sound successions in a rhythmic way. We weave a rhythm pattern into the ticking of a clock and into the clicks of the wheels on a moving train. We do not have to make an effort to get the effect; it is difficult *not* to get it.

A musical tune is perceived as an event, just as visual acts

are perceived as events. The rhythmic pattern is the basis of the grouping, and the tone differences complete the effect. The development of tune-perception may be observed in the army bugle calls. When you first hear them, they appear as mere tone-successions; one call seems scarcely different from another. After a time the tattoo, reveille, taps, and other calls acquire individuality, like the familiar visual objects of every-day life.

Illusions. — Our perception of the qualities and relations of objects is remarkably exact. It tallies very closely with the qualities and relations of the objects themselves — far more closely, indeed, than would be expected from a study of the senses. The fact that the visual receptors are located in one place, the auditory receptors in another, the taste bulbs in a third, might lead one to suppose, if he had no senses of his own, that a human being would see things in one place, hear them in another, and so on. The fact that separate nerve paths lead from each rod and cone in the eye and from each touch corpuscle in the skin to the brain, and that the various sense centers are some distance apart in the cortex, would confirm this supposition. Yet the opposite is true. We tend to group our sensations into relations just like those of the objects which arouse them, and we project all our various sensations — visual, auditory, and the rest — from any given object into one and the same set of space relations. We perceive it as *one* object.

Considering the intricacy of the perception process and the number of factors involved, it is certainly not remarkable that our perceptions are sometimes inexact — that they do not always show us the true relations of objects in the environment. Perception depends largely on habit, and when our present sensations conflict with some firmly established habit of receiving experiences, an 'untrue' perception arises. A perception which does not correspond to the actual situation in the environment is called an *illusion*.

The illusions that occur in connection with space perception are especially interesting to psychologists. Some of these have already been described. There are many others which we notice constantly in daily life. If we look at a motion picture taken from the front of a moving train, it is difficult not to get the impression that we ourselves are rushing forward. This is because ordinarily we get the *relative motion* of objects only when we move. When we look down from a tall building the people below seem very small, because the *superposition* of nearer objects to which we are accustomed is lacking, and this counterbalances the factor of their known size. The objects seen in the stereoscope appear large and distant, because the *convergence* sensations are like those that we ordinarily get in looking at distant objects.

The bits of *memory* and *imagination* that enter into our perceptions are often powerful factors in producing illusions. How many readers on first looking over chapter v of this book, read *systematic* instead of *systemic* sensations? You *imagined* you saw the more familiar word. Mistakes in printing are due to this principle. The printer's perception of words in the copy is influenced by his memory pictures; or accidental errors in composition are overlooked by the proof-reader. Such mistakes occur in the most carefully printed books. Fig. 52 is another variety of the same illusion. It is almost impossible not to see the outlines of the letter COME, even where they are actually missing.

Another class of illusions occur in pictures that can be perceived in two different ways. This *double interpretation* often occurs in geometrical patterns. Take the common oilcloth patterns in two colors. At times you see a figure of one color on a background of the other. Then it changes about; the second color becomes the pattern and the first is the background. Fig. 60 is a whimsical case of double interpretation. Does the picture represent a rabbit or a duck?

Often this sort of illusion results in *reversible perspective*.

In Fig. 61 you can perceive the black faces either as under surfaces or as upper surfaces of the cubes; in one case you see seven cubes, in the other six. The cube in Fig. 62 appears

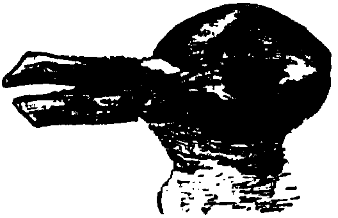

FIG. 60. — DOUBLE INTERPRETATION

Is this a rabbit or a duck? [From Jastrow, after Harper's.]

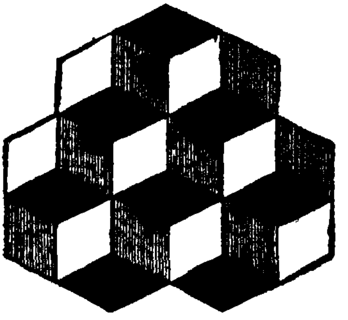

FIG. 61. — THE ILLUSORY CUBES

How many cubes do you see — 6 or 7? [From Jastrow.]

readily in two positions — either the lower or the upper central point looks nearer. With practice one can make the cube shift back and forth

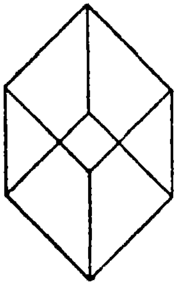

FIG. 62. — THE REVERSIBLE CUBE

Is the lower midpoint nearer you, or the upper?

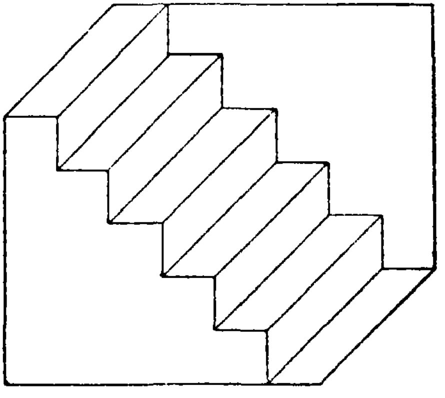

FIG. 63. — THE REVERSIBLE STAIRCASE

At first this looks like an ordinary flight of stairs. By focusing on the upper jagged line (and pulling it toward you) the staircase turns over and looks like cellar stairs seen from underneath.

at will. The staircase [Fig. 63] is not so easy to shift. We are more accustomed to see the upper surface of stairs than

their under side. If we lived in cellars the reversal would be easier. By recalling how cellar stairs look from underneath we are greatly aided in reversing the perspective; but most observers report that the upper-side effect lasts much longer than the other, even after practice.

Certain illusions are due to *eye movements* that are not properly taken into account in perception. The muscle

FIG. 64. — MÜLLER-LYER ILLUSION

The distance between apex of left and apex of central figure appears longer than that between central and right. The two distances are equal.

sensations report to us the actual movements of the eyes (or their tendencies to movement), which may be greater or less than the distances they are supposed to cover; and our perceptions overestimate or underestimate the distances accord-

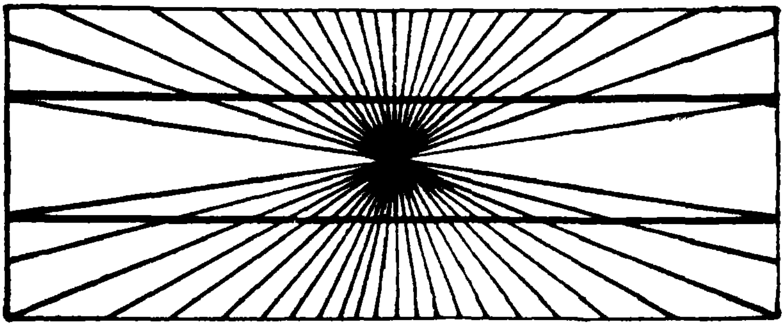

FIG. 65. — HERING ILLUSION

The horizontal lines appear to bend apart in the middle. They are parallel.

ingly. In the Müller-Lyer illusion [Fig. 64] the distance from the left point to the middle point looks considerably longer than that from the middle to the right; the two distances are really equal. In the Hering illusion [Fig. 65] the two hori-

zontal lines look 'bow-legged,' though they are really parallel. The Zöllner and Poggendorff patterns are illusions of the same sort. [Figs. 66 and 67.]

When we look at the Müller-Lyer figure, the eye does not travel from apex to apex as we suppose, but from some point

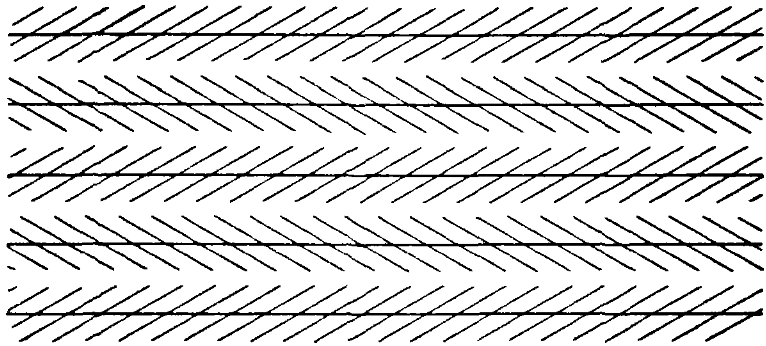

FIG. 66. — ZÖLLNER ILLUSION

The horizontal lines appear to be slightly tilted — the upper one slanting down to the right, next slanting up, etc. They are all parallel.

inside the first angle to a corresponding point inside the second, and then to a point inside the third. This makes the left distance appear longer, because the eye travels farther, with greater muscle sensations. (The eyes may not make the actual movements, but there is always a *tendency* to the movement and this is accompanied by muscle sensations, which determine our appreciation of the distance.) In the Zöllner figure the cross-lines divert the eye slightly from the horizontal path, so that the horizontal lines seem to tilt upward or downward, as the case may be. The other illusions depend on similar muscle-sense factors.

Relation of the Brain to Perception. — Perception is a higher mental process than sensation. Sensation is merely the reception in the brain centers of nerve impulses from the sense organs. Perception works this sensation material into shape. It includes *composition* of sensations, *focusing*

(attention to parts), *revival* of memory elements, and *discrimination.*

The elements which make up our perceptual experiences are chiefly sensations from the external senses, reinforced by muscle sensations and memory elements. This material is put together and modified by central nervous activities, so that the perception corresponds more nearly to the general situation in the outer world than the separate stimuli do.

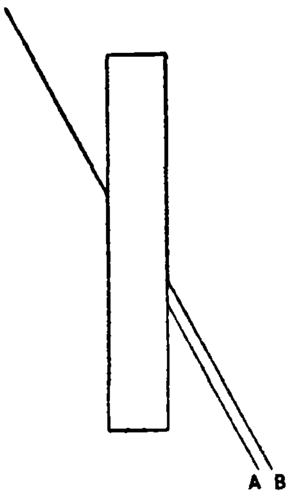

FIG. 67. — POGGENDORFF ILLUSION

The upper cross-line appears to be the continuation of the line starting at B. It is really the continuation of A.

The way in which the elementary sensations combine into perceptions depends largely upon the inherited structure of our central nervous system. Sensory neurons which lie near together in the brain and readily connect with a single higher pathway, tend to furnish group impressions. For instance, the optic nerve fibers connect together in the visual centers, so that all visual sensations which occur simultaneously tend to unite into a single experience. The same is true of auditory impressions and other types. The sight of a red disk, or the sound of a complex chord, belongs to the simplest type of perception; this simple grouping of sensations probably takes place in the primary centers. Perceptions which bring various senses together, such as the impression of a cold, heavy, glittering cake of ice, involve the use of association fibers which gather the sensory material from several primary centers into a higher center. This results in perception of objects.

The natural grouping of impressions due to inherited nervous pathways is supplemented by the retention of past

effects and previous connections in the brain. Our perception of familiar objects and common events involves something more than present sensations; it includes the memory of similar past experiences. Our perception of a friend's face when we see it in full front, includes a vague impression of his profile and the back of his head, due to memory. The more frequently we observe the same object or occurrence, with slight variations, the fuller and richer does our perception of it become. The absence of these memory elements interferes with perception, as in the case of reversed handwriting.

The highest development of perception, then, depends (1) upon the presence of a mass of inherited association fibers connecting the various sensory centers in the brain, and (2) upon the formation of definite nerve connections and paths by means of these fibers, and the retention of such effects.

Training of Perception. — The development of perception proceeds in two opposite directions — composition and discrimination. (1) Perception enables us to grasp objects and events as a whole. Common experiences are soon consolidated in this way. We see a house as a single object. It is something to live in. The front path is the means of reaching the house; the steps are for climbing, the door is for entering the house. Each of these perceptions is associated with some idea of possible action on our part. These associated ideas make up the *meaning* of the perception. The importance of 'meaning' is brought out strikingly in our experiences with unfamiliar objects. The countryman tries to pull or twist the door-bell button instead of pushing it. He does not perceive its meaning.

(2) The second direction in which perception develops is in giving emphasis to certain features at the expense of others. We pick out this or that detail which relates to our own general experience. The artist perceives at a glance some technical blunder in a painting which most of us never notice.

The ornithologist sees the nest in a high fork of a tree. The expert proof-reader's eye sometimes catches an error on the printed page before he has read a single word.

As our field of experience enlarges, our perceptions develop in both these directions even without special training. We learn naturally to see the things which bear on our own interests, and to pick out details which have special significance for us. The guide in the wilderness sees trail signs which the ordinary traveler cannot detect even when they are pointed out to him.

The need for training is rather in lines *outside* our own interests. The child at the outset needs to be trained especially in the phases of perception which do not develop readily under ordinary conditions. Sight is the dominant sense; it needs less cultivation than any of the other senses. If you compare a child's performances on the form-board [Fig. 68] with that of a grown person, you will find that the child takes much longer to fit the pieces into the right holes. Blindfold the adult and you will find that he makes the very same errors that the child makes with eyes open, and takes as long a time. The touch perception of the adult remains immature, while his visual perception has developed far beyond the child's. This means that *the average man's touch perception has not been properly trained.*

An important task in primary education should be to train perception in touch, muscle sense, hearing, and other senses. The child should be taught to discriminate and to build up object-perceptions in these fields. The special problem is to accomplish this without boring the child — to train him through play activities which keep his interest aroused. This is the underlying principle of all kindergarten methods. The Montessori system of primary education has been especially successful here.

Systematic training of perception would benefit almost every one in later life. Some of us are naturally slovenly

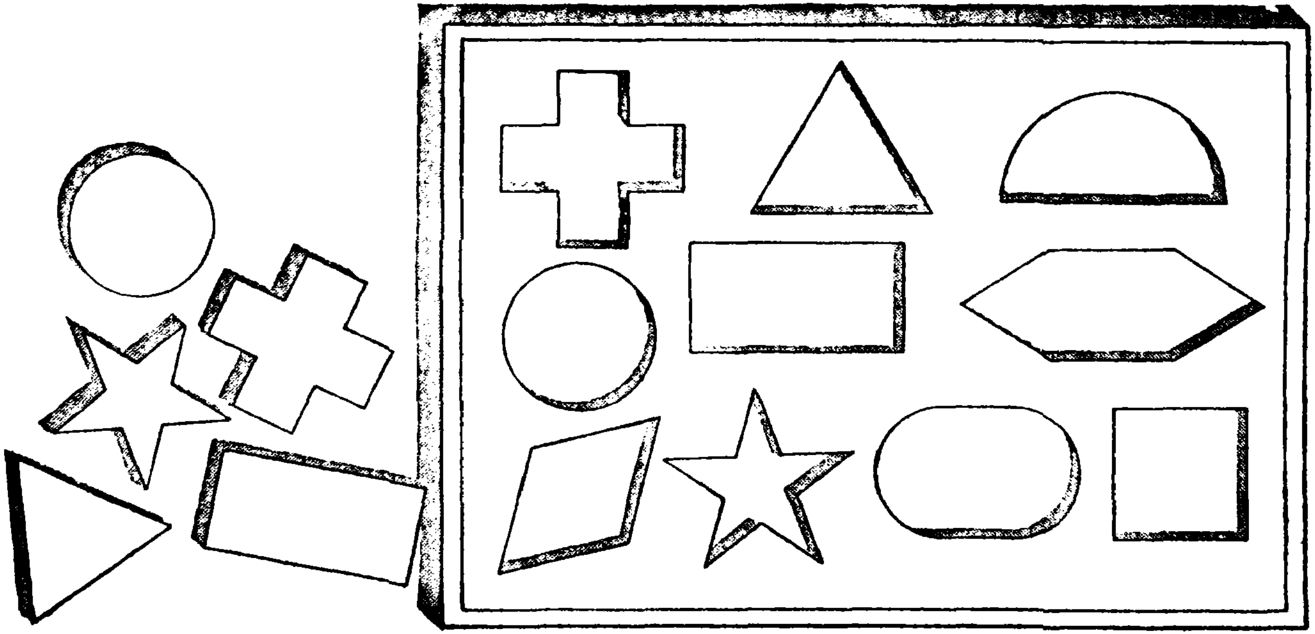

Fig. 68. — Vineland Form-Board

Each block fits into a depression in the board — none can be inserted into the wrong space. A child's visual perception and motor coördination are tested by the time required to put all ten blocks in place. Adults are tested for touch perception with eyes closed.

observers. If we realize this fault, the very realization is an incentive to train ourselves in careful observation. Perhaps we do not notice the color of people's eyes; this is not important, but it is often useful for identification. Make it a point to note the color of every one's eyes for a while; once the habit is formed it will be kept up automatically. And so of any other detail. It is impossible to observe every detail in the things about us — and too great minuteness of observation is a waste of attention. But most of us err in the other direction.

A noted conjuror tells how he and his brother made a practice of running past a show window, and then trying to describe as many as possible of the things displayed. Training of this sort would be useful to most persons. It fosters habits of more precise observation and better retention.

Summary. — In this chapter we begin the study of different kinds of experiences. *Perceptions* are composed of a great number of *external sensations*, put together so as to show us objects and events in the world around us. The most important process in perception is to get the spatial relations of things to one another (surface) and to our body (depth or projection). Perceptions are usually 'true to life,' but we sometimes misinterpret the evidence, and this gives rise to certain striking illusions.

PRACTICAL EXERCISES:

33. Examine how far your depth perception depends upon each of the eight factors mentioned in the text.
34. Place several upright rods at various distances from your eyes. Close each eye separately and observe the different effects; compare these with the effect when both eyes are open.
35. Study a pair of stereoscopic pictures with and without the instrument. Report the stereoscopic experience and its relation to the two separate pictures.
36. Observe the motions of your hand when seen only in a mirror, e.g., in shaving, hair-brushing, or writing; report the nature of your difficulties, and whether you can 'feel' your hand where you see it.
37. Test the 'staircase illusion'; note the eye movement, use of volition, time, etc., in changing from one perspective to the other.

38. Glance for one second at a shop window as you walk by. Write down what objects you perceived. Repeat for several shops and note the *number* of perceptions obtained for each.

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On Stratton's experiment: G. M. Stratton, in *Psychological Review*, 1897, 4, 341–360, 463–481.

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CHAPTER VIII

MEMORY AND IMAGINATION

Imagery. — Human experiences consist largely of perceptions of the things around us and reproductions of these perceptions. Our perceptions may be *reproduced* in the form of *ideas*, when the external objects are absent. There are two stages in the growth of ideas: *imagery* and *thought*.[1] Images appear earlier in evolution than thoughts and bear a closer resemblance to the original perceptions. Mankind is capable of several kinds of imagery:

Memory images
Imagination images
Anticipation images
Composite images
General images

Memory and imagination occur the most frequently and are very important in human life, especially among civilized peoples. A memory reproduces more or less exactly some former experience, while an imagination is unlike any previous perception. You *remember* what actually happened to you; you *imagine* things that never happened to you before. But imagination images are not composed of new material: every part of the experience is the reproduction of some earlier sensation; the originality consists merely in working these bits together in a new way.

Some of our memories are also imaginations. We may remember something we have already imagined, instead of what we have already perceived. As children my chums and I imagined a weird, fantastic vehicle called a Gobblestraw, in which we fancied ourselves riding. To-day I can remember

[1] Thought is a higher type and will be treated later (ch. xiii).

this imaginary coach as well as any real carriage; the experience is a memory image of an imagination image, because the vehicle never existed.

An image is not necessarily a visual experience — it may belong to any of the senses or to several. We remember tunes and odors. We can imagine hearing a friend say things which he never actually said. In popular language the word *image* is usually applied to something visualized; in psychology it is used in a broader way, to include reproduced sensory experiences of *every sort.*

The chief distinction between images and perceptions, when we compare them as actual experiences, is a difference in *intensity.* Memories are like the original perceptions so far as qualities are concerned — but they are ordinarily much fainter. Compare your memory of a thunder-clap with the real thing; or compare your memory of how your room looks with the actual perception. The feeble intensity of the image in each case is striking. We usually know at once and without question, from the very nature of the experience, whether it is a perception of something outside our body, or merely a mental reproduction.

Images of systemic and motor sensations may occur as well as images of external things. At times we have experiences of this sort, but they do not count for much. This is because we can usually arouse systemic and motor *sensations*, so that we do not need to *imagine* or remember them. When you imagine yourself getting angry you assume a certain bodily attitude which arouses actual sensations of anger. If you remember making a certain movement your muscles tend to contract slightly and you get muscle sensations instead of muscular memories. So it comes about that systemic and muscular memories and images do not often develop into important experiences. External stimuli cannot be so easily controlled as our own bodily processes and muscular movements; we cannot see or hear things unless the objects are

there to stimulate our senses. This lack is met by the development of imagery, which supplements our perceptions.

Nature of Memory. — If some one asks you what you had for breakfast this morning, you at once get a mental picture of the dining-room with the table spread for the meal. At each seat is a napkin in front, a fork and small plate to the left, a knife, spoons, and a tumbler to the right. You picture other definite details of the meal, including the taste of the prunes, and the uncomfortable warmth of the coffee-pot handle. All these items are part of your *present* experience; but they are not perceptions. No such stimuli strike your eyes or mouth at the present moment.

What causes the memory experience? It is started by the question that was asked you. You heard the word *breakfast*. The nerve impulse which brought up this word in your center for hearing finds a path open into another center in your brain, in which there are deep traces left by your breakfast experience this morning. Because of these traces the nerve impulse, when it passes into that center, takes a form *similar* to that during the previous experience, when you were actually breakfasting; so that you have memory images like the perceptions which occurred at breakfast time.

Every memory, or at least every actual recollection, is due (1) to traces left in the brain substance by past experiences, and (2) to some new nerve impulse which enters the region where these traces have been left, and causes activity of the same sort as before. The two essential factors in memory (and in imagination as well) are *retention* and *revival*.

The popular notion of memory is that the image itself is stored away in the mind or brain. This is not true, though one can readily see how the notion arose; it is merely attributing to memory what actually occurs in perception. Objects in the world about you continue to exist even when you do not perceive them. You see the breakfast table, you go out of the room, and when you return you see the table again;

it is there all the time. Men naturally assumed that mental images continue to exist when we are not observing them, just like objects.

The truth of the matter is that the memory image does not persist, but only the *traces* in the nerve substance. What remains within the brain is not a *picture* of the object or event, but a *record*. This lasting record does not resemble the object, nor is it like the original sensation. It is analogous to a phonograph record, where the traces are not at all like the words or music which they represent, but are capable of bringing about a repetition of the words or music under proper treatment. Like all analogies this is not quite exact. The memory image is not produced by a needle or anything like a needle. The truth is that the present nerve impulse is shaped by the traces into the same form as the previous nerve impulse.

Besides (1) *retention* and (2) *revival*, there are two other factors in memory: (3) *location* in time and space, and (4) *familiarity*. These belong to memory alone, and distinguish it from imagination and other sorts of imagery.

Location means that a memory is always given a more or less definite setting in time and space. In the case of the breakfast memory, your image is projected out from this room into the dining-room of a certain building in this town (spatial setting) and is projected back to this morning (temporal setting). The recollection of my first trousers is definitely located in a certain New Jersey village and in May or June of a certain year.

The projection of memories is neither so definite nor so instantaneous as the projection of perceptions. Often you recall that you 'have seen this person before' without any clear idea of *where* or *when* it happened. In projecting a memory image we fill in the intervening space and time between ourselves 'here — now' and the original occurrence 'there — then' by means of clues, just as we use clues in depth perception; but memory projection is not so vivid nor so

convincing as perceptual projection. When you look out of the window, the tall tree you see is unmistakably just across the street. When you look back at a certain conversation with your best friend the time and space projection may be uncertain — it may have two or more possible locations.

The space location of memories is determined by several clues, such as *prior location*, *verbal associations*, and *accompanying details*. When you recall some incident of childhood you locate the experience in your home town, because you have already built up a set of memories in which your childhood experiences are located in this place. Central Park is well known to the New Yorker. He has assimilated it to a lot of memory images. So when he recalls some event in a Central Park setting, the *prior localization* enables him at once to project the event into that place.

The memory itself may include some *name* which identifies the localization. The word 'home' and the name 'Woolworth Building' are clues that enable us at once to project certain occurrences into definite locations. These are *verbal associations*.

If we recall a town with picturesquely colored houses, the coloring may at once locate the scene in Italy. If the houses have curved roofs we project the memory to Japan or China. The memory of salt, sea-weedy odors will place the scene on the sea coast. Any such *accompanying detail* may serve to locate the memory image in space.

The time location of memory is also determined by a number of clues. Among civilized races *verbal associations* are usually the most important indication. The calendar, with its system of days, months, and years, assists us to project a memory back to the proper time. If I recall the conference of psychologists when America entered the World War, I can easily fix the time by the calendar date, April 6, 1917.

Often we have a succession of memories connected together. They occur in a certain order and the series appears in a *time*

perspective which is not unlike the space perspective of perceptions. We recall the progress of a Presidential campaign in this way — the discussion of possible candidates, the nominations, the principal addresses, and finally the election. The natural sequence of these events enables us to arrange the memories in perspective.

Even where there is no chain of memories, the *change of conditions* in the world is frequently a decisive clue. Your memory of a conversation with some one who has died, is projected back to a time earlier than the date of his death. When you recall some childish question of an old friend, the memory of his piping voice or his knickerbockers fixes the incident in boyhood days. My memory of a visit to the Windsor Hotel in New York jumps back at once to a time before that hotel burned down, though it seems much more recent.

A sense of *familiarity* is the mark that distinguishes memory most clearly from other kinds of imagery. There is a 'sense of realness' about a memory which is lacking in a mere thought or imagination. In picturing the breakfast incident there is a feeling that it *really happened* — that the situation actually existed in the physical world and is not imaginary. This feeling can be readily observed in any memory — a lecture you heard last week, a street scene some time ago, an incident of your childhood.

The feeling of familiarity may be explained in terms of nerve activity. It is due to the traces retained in the brain substance. When a nerve impulse enters the brain centers it encounters *less resistance* if there are definite traces in these centers than if it has to make a new path. This *ease of passage through the synapses* is what gives us the feeling of familiarity.

There are also feelings of familiarity associated with our *perceptions:* they occur when the same thing is seen or heard repeatedly. On returning to a town after an absence the

place looks familiar. We recognize our friends because we are familiar with their features. Certain tunes are familiar because we have heard them over and over again. Even a stranger may look familiar to us because he resembles some one we know. In all such cases the feeling of familiarity is due to the traces of similar past experiences which unite with the present impression. The perception process is easier because of these traces. Recognition depends on *ease of nervous conduction.* In recognizing persons we may not recall definitely any incident connected with them; the familiarity feeling in perception is merely a vague memory element added to the sensations which make up the perception.

Recollection. — Memory images are aroused by nerve impulses passing into some brain center and taking the form of the traces which have been left in that center. The result is that we have an experience resembling a former perception; we remember or recall the past experience. The question remains, why we recall one incident rather than another. A little while ago some one spoke of Paris, and I immediately remembered standing on the corner of the Rue de la Paix last summer looking at the Vendome Column. Why was that particular scene recalled, rather than some other part of the city?

The real explanation is that the nerve impulse which arouses the recollection passes into one center rather than another because the resistance is less in that direction; and the degree of resistance is determined by the amount of retention, fatigue, and other nervous conditions. We cannot study these nervous conditions in the brain directly, but we can observe their *results* by examining our own experiences. We can notice what sorts of memories are aroused by various sorts of perceptions and other memories. This study has led to the formulation of certain fundamental principles which are called the *laws of association,* because the most impor-

tant thing in recollection is successive association or suggestion.

The discovery of the laws of association was one of the earliest accomplishments of psychology. Aristotle, the father of the human sciences, took up the problem nearly 2300 years ago and concluded that association proceeds according to three principles: Similarity, Contrast, and Contiguity; that is to say, a perception or idea calls up an idea of something which either *resembles* it, or is in striking *contrast* with it, or was formerly *near* it in time or space. Since Aristotle's time it has become evident that contrast is not a real principle of association. Black does not suggest white much more readily than it does blue; any color may suggest any other through general *similarity* — because they are all colors. A giant does not suggest a dwarf unless we have seen a giant and a dwarf together, and this is a case of *contiguity*.

The two remaining principles, *Similarity* and *Contiguity*, have been confirmed as fundamental laws of association. Memories, imaginations, and thoughts are aroused either (1) through their *resemblance* to what we are perceiving or thinking about at the time, or (2) through having been previously a part of some similar experience or *closely connected with it*.

When you see a stranger and are reminded of some one you know, it is because the stranger looks like your friend or acts like him — *similarity*. When you hear the name of Abraham Lincoln and think of the Emancipation Proclamation it is because the two ideas have been *closely connected together* before. The thought of Paris led me immediately to remember the Vendome Column, because the Column was part of my former experiences of Paris.

Contiguity and similarity are not independent principles: they work together. The stranger resembles your friend; but when you recall your friend, your memory picture includes some features in which he is unlike the stranger. These are recalled by contiguity. It is more exact, then, to regard the

law of similarity and contiguity as a single principle, though usually one of the two factors is more prominent than the other.

LAW OF SIMILARITY AND CONTIGUITY: An experience tends to recall another experience which resembles it in part, the dissimilar elements being such as were closely connected with that other experience in space and time.

We have still not answered fully the question raised at the outset — why this particular memory or thought is aroused rather than one of a dozen others. Many persons you know are more or less like the stranger — why do you recall just this one of your friends? You have heard of many things connected with Lincoln. Why do you recall the Proclamation? The law of similarity and contiguity does not explain the facts completely. It must be supplemented by certain *other principles, which are called quantitative laws of association.* There are three important quantitative laws which determine the selection of ideas: *frequency, vividness,* and *recency.*

(1) LAW OF FREQUENCY: An experience which has been *repeated* many times tends to be recalled as a memory or thought more readily than an experience which has occurred in the past only once or a few times.

We recall the name or looks of a friend much more readily than we recall a stranger. The same law holds for verbal memory; we tend to recall far more readily phrases we have memorized than those we have heard only a few times. The law may be explained in terms of nerve activity: Repetition improves the synaptic connections between neurons, and this facilitates thereafter the passage of nerve impulses along the same path.

(2) LAW OF ORIGINAL VIVIDNESS: Among alternative ideas, any one of which might be recalled, that particular one tends to be suggested which was more *intense or vivid when it occurred originally* as a perception or thought.

We tend to recall more readily an important or thrilling experience than one which we did not attend to; vivid thoughts and clean-cut phrases are most apt to be recalled. The explanation is that an intense nerve impulse tends to leave a deeper trace in the neurons through which it passes, and this makes these neurons more fit to receive future impulses.

(3) LAW OF RECENCY: A recent experience is more apt to be recalled than an experience which occurred some time ago.

We recall many more events of the past week than occurrences dating back a year or ten years. This is because a nervous path which has recently been used is more passable than paths which have not been used for a long period of time. Connections in the central nervous system tend to become more resistant through disuse.

The factors of *frequency*, *vividness*, and *recency* often conflict. A *vivid* experience which occurred many years ago may be recalled more readily than a *recent* experience of lesser vividness. Frequent *repetition* may strengthen a *remote* experience. On the other hand an experience which has never been attended to — which lacks vividness — may not be recalled even though it has been repeated many times. We all know how hard it is to remember a set of instructions on a subject which is entirely outside our interests, no matter how often they are drummed into us.

Forgetting. — Why do we fail to remember certain things — especially proper names — though we try our best to recall them? Often when you start to speak about some one whom you know perfectly well, you suddenly find you are unable to recollect his name. You cannot recall whether you locked the door or turned off the light downstairs. You put a paper away very carefully for future use; and now you have not the slightest idea where you put it. You make a dinner engagement two days ahead: when the time comes you forget it.

In the case of proper names there is often a vain struggle to

remember. We think of several names one after the other, and reject each in turn, recognizing at once that it is not the right one; — it lacks the feeling of familiarity. Sometimes we go down the alphabet systematically, trying out each letter in turn, and perhaps strike the right word as a matter of chance. The attempt to recall a man's name by picturing how he looks is generally futile. If we dismiss the subject completely it often happens that the desired name suddenly 'jumps up in consciousness' — it may be in a minute or within an hour, or perhaps only after several days.

The subject of forgetfulness has not been studied so thoroughly as memory and recollection. But the following principles have been noticed: they apply not merely to names but to memory lapses of all sorts.

(1) Conflicting Associations: If another thought, similar to the one we are trying to recall, is present, it tends to fix the attention and exclude the desired thought. This accounts for most cases of inability to recall names. I cannot recall the name of my Latin professor, Dr. Packard. The name of Dr. Patton has come up first and holds the field, preventing the other association. I meet an old acquaintance after several years and am at a loss for his name; I can only think of Lamson — not because the name sounds like Lamson but because the man looks like Lamson, whom I have seen more recently.

(2) Faintness: If an experience was not originally attended to, or is not recent, or has not been repeated, it is difficult to recall it. You do not remember whether you have locked the door because the action was quite automatic; you did not pay attention to it. You forget where the paper was laid away, because the occurrence took place some time ago. In a city we pass many people daily on the street; if we chance to pass one of them a second time we fail to recognize him unless there is something striking about his appearance — that is, unless the original impression was vivid.

This law of faintness is simply the negative side of our three laws of recall.

(3) INHIBITION: If an experience is painful or is accompanied by some unpleasant emotion, the recollection tends to be *inhibited*. If you have done something you are ashamed of, every time you recall it you dismiss it from thought by passing as quickly as possible to something else. In this way the tendency to recall this particular thing is continually weakened till at last the association may be entirely inhibited. Some writers describe this as a 'repression' of unpleasant ideas into the subconscious field. The process is really not a repression but a weakening or inhibition of associations.

The influence of frequency and recency on the rate of forgetting may be studied experimentally by committing to memory several series of nonsense syllables. Meaningless syllables do not differ in vividness like words, so that one series makes the same impression on you as another. If you take two different nonsense series, and repeat one a great many times and the other only two or three times, you find that very much more of the former is retained. If you repeat several nonsense series the same number of times and try to recall one after one day, another after two days, and so on, you can determine how much you forget as time goes on. This is shown in Fig. 69. The curves (which represent the amount *retained*) drop decidedly at first, and less and less thereafter. In other words, the amount of loss is greatest at first; and there is less additional loss as time goes on.

It is often asked whether any experience is really forgotten — whether all traces in the brain substance persist indefinitely, or if some wear away completely in the course of time. Instances are cited of events in early life which are recalled after an interval of many years. In two cases recently reported, men of ninety repeated orations which

they had learned in boyhood and had apparently not recalled meanwhile. In both these cases the lines were originally fixed in memory by repetition (and interest), so that the

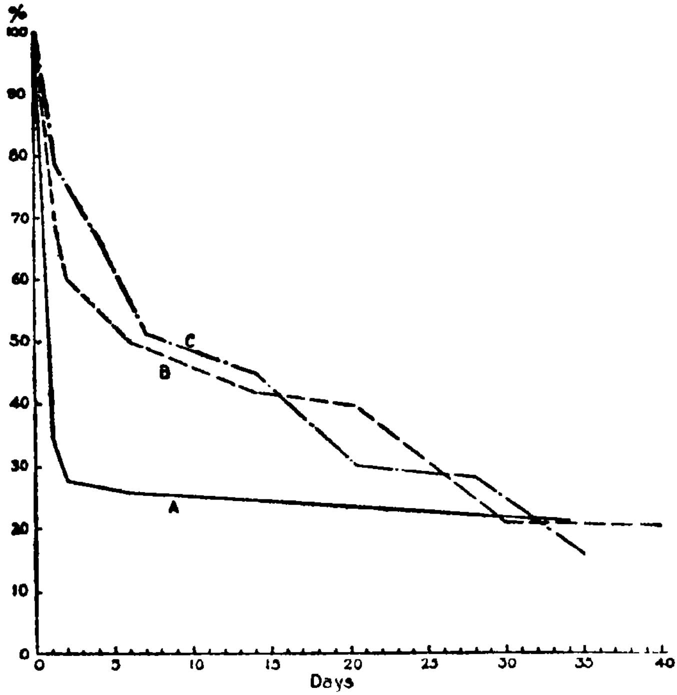

FIG. 69. — CURVE OF FORGETTING

The curves show the results of experiments on learning and forgetting by three different investigators. A and B memorized nonsense syllables. C used series of jumbled letters. The curves show the percentage recalled after various time intervals. (After Starch.)

recollection was not the revival of an isolated experience. James cites the case of a very young woman who could neither read nor write, who during a fever uttered sentences in Latin, Greek, and Hebrew — languages with which she was wholly unfamiliar. It was found that during her childhood she lived in the family of an old clergyman, who was accustomed to walk up and down reading aloud in these lan-

guages. Passages repeated by the woman were found in books from his library. The impressions had been retained many years without either repetition or original vividness.

Whether any memory is utterly lost is uncertain.[1] It is safe to say that far more is retained than we ever actually recall. It may be that in the normal brain every trace persists indefinitely. Or it may be that the traces wear away, or are gradually effaced by other traces. Too little is known at present about the nature of memory traces to answer the question definitely.

Training the Memory. — The practical value of a good memory is too obvious to need discussion. One of the most frequent questions put to the psychologist by outsiders is: Can you help me to improve my memory? A good memory means ability to recall what we want when we want it. This depends on several different factors: (1) perception; (2) the learning process; (3) verbal association.

(1) PERCEPTION: Certain sorts of memory depend essentially on accurate perception, and the obvious way to improve them is to train our perceptions. The memory for faces is a good example of this. Contrast the man who recognizes at a glance a person whom he has not seen for years, with the man who is always in doubt as to the identity of the people he meets. The one has been accustomed from childhood to perceive faces accurately; recollection takes place automatically. The other has never trained himself to observe faces carefully. Often the deficiency is due to defective eyesight. Near-sighted and astigmatic persons do not see faces clearly; they cannot recall them because they have never registered the distinguishing marks. Such persons may recognize a man instantly by the tone of his voice.

Another sort is the memory for scenes and incidents. We often wish to describe scenes or events to friends — some-

[1] If one of the brain centers is destroyed by disease or accident, the traces in that center are gone, and with them the possibility of certain recollections.

times we are asked to testify about them in court. Accurate testimony depends on accurate perception. The witness who told of a man "pacing to and fro, his hands behind his back, reading a newspaper," must have observed rather carelessly. It may be of life-and-death importance to recall which of two shots was fired first. In thrilling moments accurate perception is difficult. The discrepancies between the testimony of witnesses is often due to the disturbances of perception wrought by the excitement of the moment; it is no reflection on their sincerity or mental ability. Nevertheless a careful training of perception will prevent many errors.

(2) LEARNING PROCESS: Memorizing poetry and speeches so that we can repeat them accurately depends on the learning process (ch. xi). It is not a matter of accurate perception, but of repeating the words over and over so as to strengthen the retention traces in the brain centers. The ability to memorize quickly is largely a matter of inheritance; that is to say, the inherited nervous system of some persons is such that they readily retain long series of impressions and reproduce them in the right order. But our inherited capacity may be strengthened by training and impaired by disuse. Self-confidence is an important factor here. If you feel sure you will succeed, many slips are avoided which would occur if you distrust your own ability to repeat a speech.

(3) VERBAL ASSOCIATION: The ability to recall names depends largely on verbal associations. The names of common objects are learned early in life; through constant repetition the word *table* becomes an integral part of our perception and thought of a table. The normal man finds no difficulty here. It is the memory for proper names that troubles him. Henry Brown may have light hair or black hair — the association of the word *brown* with the man Brown is arbitrary. We meet the same difficulty in learning a foreign language unless the words are similar to our own. The French word *fromage* is difficult to associate with *cheese.*

Language is a higher mental process than perception and imagery.[1] The understanding of words involves brain centers at a higher nervous level than the perception centers. The act of associating words with perceptions (or with mental images) is different from ordinary association; it follows much the same principles, but it is a more specialized process. Verbal memory may be improved to some extent by training. In old age it is the first to deteriorate; witness the struggles of elderly persons to recall the names of their best friends and even of their own children.

Statistical data belong in the same class. The date of the discovery of America, the rate at which sound travels through the air, the population of Chicago, are arbitrary associations of numbers with events or objects. Much of our scientific knowledge is of this sort. There are certain facts that "every educated man ought to know." How far to insist on such knowledge is a serious problem. Teachers are inclined to attach undue importance to this kind of memory. Encyclopedias and reference books are generally available, and it seems useless to burden the child's memory unnecessarily. He should of course be taught the addition and multiplication tables, weights and measures, and other fundamental statistical matters. But in the higher education it seems more important to teach the student *where to look for information* than to take up his time in memorizing arbitrary number associations.

Certain devices have been invented to assist this sort of memory. The figures are associated with letters of the alphabet (consonants), and a catch-phrase is made up which brings together the number and the fact. Let b=1, g=4, r=9, d=2; then the number 1492 is represented by b, g, r, d. We invent the phrase, "Columbus made a *big raid* on America," and thus remember the date. Many persons find such a system useful; others find they get on quite as well without it.

[1] See ch. xiii.

There is danger of course that the phrase may be twisted. If we think that Columbus made a '*bad raid,*' the discovery of America would be shifted to 1292.

Imagination (Fancy). — An *imagination image* or fancy is an image composed of elements from two or more separate experiences. A typical example is our mental picture of a centaur, which combines the head and arms of a man with the body and legs of a horse. This image is a combination of two separate perceptions — unless it happens to be the memory of some picture or statue we have seen. The scenes in a novel or history, as we mentally picture them, are imagination images. We piece together bits from familiar experiences suggested by the narrative, and construct scenes which may be quite different from anything we have ever witnessed. The plans of an inventor in the earlier stages are imagination images; they are pictures based on real experiences, but are unlike anything the inventor has actually perceived.

Some of our fancies are so fantastic that we are apt to regard them as absolutely different from our perceptions. This is not the case. The elements composing the image are often much transformed from the original, but they are always *derived from former sensations* of some sort. On the other hand it does not follow that every fancy represents some reality or possible reality. An imagination image is novel in just the same way that an invention is novel. The finished product is new, but not the materials.

The practical working of imagination will be better understood if we study its manifestations in children, before it has been overlaid with higher processes of thought and molded into definite lines by our interests in life. The child is naturally imaginative. He pictures the fairies and monsters of his story books vividly. He hears animals talk, he sees inanimate things acting like living creatures — all this as distinctly as though the experiences were actually *remembered.* There seems, in fact, to be no sharp distinction in early life

between memory and imagination. The child tells of imaginary adventures with the same sense of reality that he feels in describing real occurrences. Many of the child's lies have no ethical significance whatsoever, — though their psychological significance may be most important, as indicating the nature of his mental processes.

These facts indicate that in early childhood imagination is as fundamental as memory. Both depend on retention and revival. Memory is revival of definite groups of retention traces, while imagination is the revival of separate traces which are grouped together into new experiences. It appears that imagination is really not distinguished from memory in early childhood. This is probably because memory traces are not yet deeply fixed, so that the revival is not accompanied by a strong familiarity feeling.

As the child's mind develops, the distinction between memory and imagination grows more definite. Memory images are recognized as such by the accompanying familiarity feeling and by their setting in space and time. The distinction is fostered socially by the punishment or disapproval which follows when the child tells as fact what really belongs to the realm of imagination. The outer world becomes to him more and more an independent reality; his memories represent that real world, and his fancies do not.

As we pass out of childhood the imagination tends to become more restricted. Instead of being free and desultory it falls into certain definite grooves. In one person it tends toward artistic creation, in another toward invention; one man seeks to explain the mysteries of nature, another proposes to reorganize society. In this way various types of imagination arise, based on the special life interests of the individual. Esthetic, creative, scientific, and social or ethical imagination are broad general types; under them we find many subordinate types, such as pictorial, musical, and graphic imagination.

Other Kinds of Imagery. — Besides memory and fancy there are several other sorts of images. *Anticipations* are images which picture our future actions and lead to some appropriate activity on our part. Both voluntary and involuntary acts may be preceded by anticipation images. My mental picture of a ball game scheduled for this afternoon leads me to walk down to the field. The nerve impulses concerned in this image are part of the set of operations in the nervous system which start the appropriate movements.

Anticipation images are similar to fancies except for their 'prospective reference.' A fancy may suddenly blossom into an anticipation — when the painter starts to paint or the inventor begins to build his machine; an anticipation image withers into mere fancy when our plans fail.

There are two reasons for emphasizing anticipation as a distinct sort of image. First, because it is intimately connected with our active life. Anticipation, or purpose, is more efficient than imagination in bringing about suitable responses; and this after all is the vital point in mental life. Second, the anticipation image arose earlier in animal evolution and appears earlier in the human child than fancy. Image experiences seem to have arisen in the first place as a method of reaching into the future, not as a means of bringing back the past or of picturing novelties. When a baby cries for milk, he has probably a faint anticipation of getting it. The dog who jumps about when his master appears in hunting costume would seem to have a rather vivid anticipation of what is going to happen.

A *composite image* [1] is built up through frequent repetitions of substantially the same experience. It is a more perfect reproduction of past experiences than an imagination, but it is less definite than a memory. The effect of this repetition is to weaken the general setting, which is different in each case. The image represents some object we have actually

[1] Also called a *free image.*

perceived, but it shows the object without any definite location in time and space and with no fixed surroundings or background. You often picture the face of a friend or a familiar tune without special reference to time or place or circumstances; the image is a composite effect of many past experiences. The repetition strengthens the accompanying feeling of familiarity, and usually adds something to the image itself. The composite image of your friend's face usually includes both profile and full front views, and the composite image of a house may include both inside and out, which we never perceive or recall in the same picture.

A *general image* is due to the fusion of many similar images into a single experience. It arises from the perception of a number of objects which are *partly similar* and *partly unlike*. When the child has seen a number of men whose general appearance is the same, but with certain differences, he begins to form a mental image which embraces their common features. These common points are vivid, and make up the focus of the image; the details in which men differ appear only indistinctly in the margin of the conscious field. In the same way the child forms a general image of a horse and of various other sorts of creatures and objects.

Our general image of *horse* in adult life is probably based on memories of a certain horse — it may be an old bay mare we knew in childhood. Attached to this memory are a variety of different characteristics, such as gray and black, long-tailed and bobtail, stocky and slim, derived from our experiences of other horses. These points of difference between horses are only faintly pictured in the general image, while the characteristics common to all horses are emphasized. In other words, our general image of *the horse*, though based upon some particular animal, is not stocky nor slim, it has no distinctive color, no special trim of the tail; many of the features and outlines are vague. The prominent elements in the general image are those details in which *all*

horses agree, and which distinguish horses from other creatures.

In adult life the general image rarely occurs in a pure form; almost always a word or symbol of some sort attaches to it, and it becomes a *thought* (ch. xiii). Thought is a higher type of experience than the general image.

Illusions of Memory and Hallucinations. — We often make mistakes in interpreting our image experiences, just as we make mistakes in perception. Two different sorts of errors occur in connection with imagery: *illusions of memory*, and *hallucinations*.

Illusions of memory are due to our misinterpreting some factor in the experience. The most common illusion is based on the 'location' factor. If the memory of an event includes only a few details it is easy to refer it to the wrong time or place. I recall a conversation with a friend; the surroundings are not definitely recalled, and I imagine it occurred when we met in New York; actually the discussion took place at another meeting elsewhere.

It often happens that the memory of a certain event remains unusually vivid, so that we place it much too near the present time. The opposite is true when we move to a new town and quickly grow familiar with our surroundings. We soon get the feeling that we have lived there a long time; the older background tends to fade into the distance.

Another illusion consists in mistaking an imagination for a memory. I remember distinctly posting a certain letter, and assure my wife I did so. When the letter turns up later in my overcoat pocket the 'memory' proves to have been merely a vivid imagination. Usually this sort of illusion is due to the mingling of imagination elements in a memory picture. I remembered taking the letter but I imagined the post-box part. The inaccuracies of court testimony are often to be explained in this way. You describe a man in a brown suit and a derby hat. Your description is correct except that the

suit was gray and he wore no hat. These details were added (quite innocently) from the imagination.

Such illusions are often due to the fact that you first imagine certain details and then remember your imagination. Who has not related incidents of family history that have been handed down through the years, and felt certain he witnessed them? — only to discover that they occurred some time before he was born. They are memories indeed, but memories of narratives that have been told him — memories of the vivid fancies which he formed on hearing the stories in childhood.

An *illusion* is the wrong interpretation of certain factors or elements in the experience. An *hallucination* is the confusion of images or thoughts with perceptions.

We have usually no difficulty in distinguishing images and thoughts from perceptions. One distinguishing mark is *intensity*. Most mental images are far less intense than any perception. You know that the table before you is real; the experience is too intense to be due to anything but an external stimulus, and consequently the experience is a perception; you know just as certainly that the tune 'running through your head' is imagined; it is far weaker than real music.

Another factor which enables us to distinguish perceptions from fancies is that perceptions are *independent of our control*. They come and go according to their own sweet will — not as we wish. If we can call up or alter a certain experience at will, we class it as a memory or fancy.

These two factors, *intensity* and *controllability*, generally coöperate, and prevent hallucinations. But they are not infallible tests. Some perceptions are faint and some fancies are vivid. On dark nights we are not certain what we actually perceive and what we merely imagine. Dreams are vivid fancies; for the time being they appear to be perceptions, since we have no external sensations to compare them with.

In states of high-strung tension one sees a specter, or hears voices warning him, though the experiences are mere fancies.

If the object seems to act independently of our control, the error may be reinforced, or our uncertainty may be greater. In such cases the normal individual falls back upon a third test, the uniformity and *general consistency of experience.* We convince ourselves that the 'specter' is imagined, that the 'voice' is within us, because such experiences do not conform to the general scheme of things. Even in dreams we sometimes notice the inconsistency of the experience with other circumstances and realize that we are asleep.

The characteristics by which we distinguish imagination from perception are merely practical tests, based upon the general run of our experiences. In most cases there *is* a sharp dividing line between them, and the bulk of our experiences fall naturally into one class or the other. But neither the experience itself nor its elements furnish a decisive indication of the original source. *Both imagination and perception are due to brain processes;* either may readily be mistaken for the other if its general characteristics fall within the border-line territory.

In certain mental diseases the patient ignores the test of consistency, and systematically mistakes his fancies for objective reality. These pathological states are *delusions;* they are a stage beyond *hallucinations.*

Importance and Training of Imagery. — Memory and imagination are of varying importance in human life. As we advance in civilization the use of imagery develops more and more into *verbal thinking* and the use of image pictures tends to become less active. In certain occupations imagination is especially serviceable and deserves cultivation. The 'creator' of every sort — whether artist, writer, or inventor — is helped by the cultivation of exact and vivid imagination; the professional man, the scientist, and the business man usually find verbal thinking more useful.

Nikola Tesla, the inventor, attributes much of his success to his power of visualizing distinctly, and in detail, the machine which he wishes to devise. The whole idea is worked out mentally before ever a sketch is put on paper. "In my mind I change the construction, make improvements, and even operate the device." [1]

The exactness and vividness of imagery depends largely on our ability to observe our perceptions exactly. The training of perception is essential to accurate memory and vivid imagination. This must be supplemented by practice in recalling events in detail and by constant exercise of the imagination. The cultivation of imagination is useful only in certain lines of work; but memory training is of general utility.

It is a matter of great social importance to be able to distinguish clearly between true memories of objective events and mere fancies. Lying has an ethical significance. It is more than a 'psychological phenomenon' in the adult. For this reason it is important for every man to learn to distinguish clearly between truth and fiction. Fancy *as fancy* has a legitimate place in mental life. Like play and jesting it relieves the strain of our more serious occupations. The most earnest mental worker finds relaxation in pure horse-play, and the most rigid logician heartily enjoys a pun. The attitude to be cultivated is one of absolute sincerity in matters of fact; we should discriminate clearly between objective facts or truths and the constructions of our own imagination. The more completely we separate these two spheres, the better can we appreciate the fantastic tales of Wells and the subtle exaggerations of Mark Twain.

Summary. — In this chapter we have examined *imagery*, an experience which owes its characteristics to brain traces of former experiences — not to the present stimulus. Most images are revivals of external sensations; though occasion-

[1] Quoted in *American Mag.*, April, 1921, p. 62.

ally other kinds of sensations are revived. The most important sorts of imagery are *memory* images and *imagination* images (fancies). Memory reproduces some perception we have actually experienced; an imagination is made up of bits of former perceptions, gathered here and there and put together into a definite image.

PRACTICAL EXERCISES:

39. Take at random some date between six months and a year ago. Try to recall as many incidents as possible that occurred on that day.
40. Take some notable event in your recent life (over six months ago) and describe the scene and the succession of occurrences as minutely and accurately as possible.
41. Lying in bed at night with closed eyes, try to picture imaginary scenes or stories. Describe the experiences; compare their vividness with real scenes; how far are they due to retinal stimulation?
42. Read a description of a scene or event from some novel or history, and note the images which are aroused. Classify them as visual, auditory, etc. Grade them according to vividness.
43. Describe any experience you can recall where you have mistaken an imagination for a perception or vice versa, or where you were unable to judge its real nature.

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CHAPTER IX

FEELING AND EMOTION

Affective Experiences. — The experiences we have examined so far have to do with objects and conditions outside our own body. Perceptions are made up for the most part of sensations which come from the outer world. Memories, imaginations, and other images are made up chiefly of reproductions of these same external sensations. Perceptions, images of all sorts, and thoughts (which we shall discuss later) all belong to the same class of experiences, which are usually called *cognitions* or *intellectual experiences.* The responses that we make when we perceive or remember or think are movements which have to do with conditions *outside* us, in our environment — not inside our own body.

We now come to a different kind of experience — experiences which are made up chiefly of *systemic sensations* or in which systemic sensations are especially prominent. These experiences are concerned, first and foremost, with the *condition of our bodily organism* — not with events in the surrounding world; though our body and our environment are too closely related to make the distinction complete. They are called *affective experiences,* and include the following sorts:

Feelings
Emotions
Sentiments

FEELING

Nature of Feeling. — A *feeling* is an experience in which systemic sensations are the main elements.[1] Feelings are

[1] *Feeling* is also used to denote any *indefinite sensation.* This is an older meaning of the term. It is still kept, because the expression 'I sense' has

made up of organic or pain sensations or both. The feeling of hunger which we experience before a meal is due to organic sensations; a toothache is a very pronounced feeling derived from the pain sense. The feeling of general well-being which pervades our body after a hearty meal is based on our 'general sensibility' — on the condition of the body as a whole.

Systemic sensations have not only their own special qualities like the external senses, but also a common *feeling tone:* they are either pleasant or unpleasant. When systemic sensations combine into feelings, their special qualities usually fade away and the prominent feature is their pleasantness or unpleasantness.

This is the opposite of perception. When you look at a picture you perceive and discriminate its various parts; they do not merge together. In a feeling, the greater the number of sensations entering into the experience, the less distinct are their details; you feel more and more an indefinite pleasantness or unpleasantness within you. A pin-prick is definitely localized and stands out sharply. When you fall and are bruised, the feeling of *hurt* seems to spread over a large part of the body in an indefinite way. When you have a certain pain in the region of the teeth, you are not always sure whether it is merely toothache, or toothache combined with earache. It is localized now in one place, now in another. The most prominent feature of these experiences is the 'hurt,' or sense of discomfort — not the *kind* of hurt or its location. The same is true of pleasant feelings. It is difficult to locate the feeling of 'thrill' or to analyze its quality.

Our mental life at any moment is generally tinged with a pervasive feeling of some sort. If the general tone is pleasant the feeling is one of happiness or euphoria; if it is unpleasant the feeling is despondency. We rarely have two conflicting

never come into general use; but we must be careful not to confuse the two meanings. It is advisable not to use feeling for the sense of touch; this is too confusing. The old English word 'to palp' is better.

feelings at the same time. In fact, it is sometimes stated that pleasantness and unpleasantness cannot be experienced together at the same time. This is one of those popular generalizations which we must learn to challenge. Under some conditions it is certainly possible to experience two conflicting feelings at once. We are pleased when a friend sympathizes with us over our toothache; but this does not altogether obliterate the discomfort of the ache. In cases of this sort we do experience both the unpleasant and the pleasant together — sometimes with equal vividness.

Systemic sensations frequently form part of our perceptions of external things. Some odors are unpleasant; most musical chords are pleasant. The feeling tone in such cases does not come directly from the external stimulus, but from some organic change which the stimulus brings about. The sharp edge of a knife is not pain-*ful* but pain-*inducing;* the pain is due to the laceration of the skin and the consequent organic injury. Odors are unpleasant when they produce destructive changes of tissue within the organism. The pleasure we get from listening to music is due to certain chemical changes (anabolic processes) wrought in our bodily system by the music.

We may grow to like certain odors that were once unpleasant or to dislike tones or colors that were formerly pleasing. The change from pleasantness to unpleasantness is due to the body becoming accustomed (' hardened ') to the stimuli, so that they no longer produce destructive effects. The opposite change is probably due to some idea which works through the motor nerves on the bodily processes. If " the very thought of that fellow nauseates you," the nausea is due to nerve impulses from your brain centers to the glands of your stomach.

Many of our affective experiences come about in this indirect way. The glands which secrete the substances used in digestion, and various other internal glands (including

those of the reproductive organs), are operated by the autonomic nervous system. The autonomic and cerebrospinal systems work together. Consequently our feelings often modify our ideas and thoughts very decidedly; and our ideas often influence our bodily processes and produce very intense feelings. When a man is despondent it is sometimes difficult to determine whether his feeling of despondency is due to certain disturbing thoughts, or his thoughts of impending disaster were started by despondent feelings.

Appetite and Aversion. — Our feelings are not so well developed as our perceptions and ideas. They have comparatively few different qualities. There are several reasons for this. Systemic sensations are not so clear-cut and definite as the sensations of sight, hearing, touch, or smell. They are produced (except in the case of pain) by internal stimuli which are constantly changing and are difficult to hold. They are not so intimately connected with conditions in the environment, which are of supreme importance in the life of man.

Our internal bodily experiences are usually subordinate to our experiences of the world about us. But there are times when the organic or pain stimuli are so intense or so insistent that our experience is largely and unmistakably a feeling, with everything else in the background. These definite states of feeling are of two opposite sorts, *appetites* and *aversions*, according as their general toning is pleasant or unpleasant.

Feelings of *appetite* result most frequently from digestive and generative sensations, while feelings of *aversion* are made up of pain sensations and sensations arising from disturbed digestive conditions. In many cases the tone of a feeling is not pure. The feeling of digestive appetite, for instance, includes both unpleasant hunger sensations and pleasant satisfaction. A pain may be accompanied by pleasant sensations due to the healing process. Sometimes the feeling

tone is indefinite — it is recognized neither as pleasant nor as unpleasant. Here there is apparently a balance between the destructive and restorative chemical processes in the body. These neutral feelings are called *excitement*.

Intense feelings of any sort are apt to arouse activity of the muscles, which gives muscle sensations. When this occurs the feeling passes into another kind of experience, called *emotion*. In other cases the feeling arouses activity of the glands, which stimulates additional organic sensations and these keep the feelings alive.

Intensity of Feeling. — The intensity of feeling is difficult to measure. We do not discriminate differences of intensity among systemic sensations as exactly as we distinguish brightness or loudness. It is difficult to get at the stimuli and experiment on their changes.

Some attempts have been made to measure the changes of intensity of the feeling tone which accompanies external sensations. When the intensity of a light or sound or pressure is increased continuously, the intensity of the accompanying feeling varies at the same time. But this change does not follow Weber's Law, because feelings have two opposite phases, pleasantness and unpleasantness, while perceptions have only one. The experiments bring out the following relations:

(1) With slight intensity of stimulation the intensity of the accompanying feeling is zero.

(2) As the intensity of the stimulus increases there is at first a slight degree of pleasantness.

(3) With further increase in the intensity of stimulation the pleasantness increases to a maximum and then decreases.

(4) At a certain point the pleasantness disappears entirely.

(5) With further increase in the intensity of stimulation unpleasantness appears and thereafter increases steadily.

(6) With great intensity of stimulation a maximum degree

of unpleasantness occurs; this marks the beginning of actual destruction of some of the tissues. [Fig. 70.]

Importance of Feeling. — We are apt to underestimate the importance of the feelings in mental life because they are so overshadowed by our perceptions and other intellectual experiences. The knowledge of our bodily condition may not be so essential to us as knowledge of the outer world, but it is too important to be ignored. The influence of feeling in determining a man's attitude toward the outer world is seen if we compare the responses of different individuals under similar conditions; or if we observe how differently the same person acts in two cases where the external situation is similar but his own internal condition is radically different.

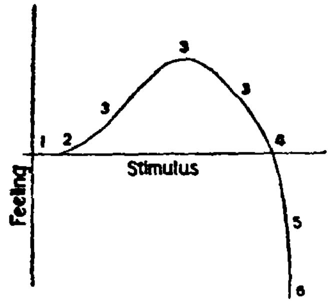

FIG. 70. — INTENSITY OF FEELING

The curve shows how the feeling accompanying a perception varies with increase of stimulation. Distance above the base-line represents degree of pleasantness, distance below represents degree of unpleasantness; horizontal distance represents intensity of stimulation. The numbers correspond to the six laws given in the text.

Some men apparently can never be disheartened or insulted; others will collapse at the slightest misfortune, or bristle at the most trivial remark. The same man who meets difficulties energetically and cheerfully when he is in good health, may refuse to face danger or perplexity when affected by indigestion, malaria, or other weakening influences. The external stimuli are alike; the difference lies in the internal bodily condition.

We can only appreciate the real significance of feeling in man's mental life when we consider its influence on the evolution of animal species. Destruction of tissue is harmful to any creature. It follows that any species or creature that develops a means of avoiding the destruction of its tissues will stand a better chance of surviving. Those creatures and

species which are able (1) to avoid harmful stimuli, and (2) to react positively to beneficial stimuli, are most likely to survive in the long run. These two opposite types of response are determined by the two opposite phases of feeling. So that any species which evolves a set of receptors and nerves for feeling has gained an additional and important means of getting along in life.

Emotion

Nature of Emotion. — Mental life is especially concerned with the interaction between the body and the outer world. Accordingly, the most important development of feeling is in connection with the motor activities which it arouses. The most significant affective experiences are not pure feelings, but feelings combined with powerful motor sensations. These experiences are called *emotions*.

An *emotion* is an experience made up of both systemic and motor sensations. It is a condition of mental excitement, either pleasurable or the opposite (usually with definite organic or pain qualities), accompanied by great muscular activity or tension, which gives rise to intense muscle sensations.

When the fire alarm is sounded your heart beats faster and your legs almost irresistibly carry you toward the scene. After a thunderbolt your heart stops beating for an instant and your muscles are tense. When you come home after a long absence, you feel a thrill of happiness and wave your arms or shout for joy. These are emotions; they consist of systemic *and* motor sensations — both very vivid.

Emotion is the only secondary experience in which ideas do not play a prominent part. An emotion is usually aroused by external stimuli or by ideas which represent things in the external world; but the perception or idea is not part of the emotion — it fades into the margin when the emotion surges into prominence. The sight of the smile on the subway

guard's face as he slams the gate on you, makes you boiling mad. But your anger is the bubbling up of inner feeling and the clenching of your teeth and shaking your fist — not the sight of the guard. The anger experience is composed of sensations stimulated by your intense physiological and muscular activity.

According to popular notions the essential ingredient of emotion is the feeling — the motor display is an after-effect. We speak of "emotion and its expression." This interpretation of emotion was generally accepted by psychologists till about thirty years ago. It assumes that we first experience the *feeling* of anger, then clench our teeth and fists, scowl, and assume the general anger *attitude*.

William James and Carl Lange independently suggested that the factors really arise in the opposite order: We first of all assume the anger *attitude* — clench our teeth and fists, and strain the tension of our muscles; these movements in turn stimulate the anger *feeling*. That is, according to these writers, *the motor sensations generate the feeling sensations which compose the experience*. Many psychologists now accept the James-Lange theory of emotion. This theory finds some confirmation in the fact that if we artificially assume the anger attitude with all its motor accompaniments (for instance, when we act a part in a play), our feelings are aroused very strongly; and on the other hand when we are really angry, if we succeed in relaxing our muscles and so rid ourselves of the motor sensations, the feeling of anger diminishes and the entire emotion tends to disappear.

However, the facts seem to indicate that neither of the two factors has precedence in emotion. Both systemic and muscle sensations are aroused by some perception or thought; both arise together, and both are integral parts of the emotion. If we succeed in relaxing the muscles, the emotion vanishes — it passes over into a simple state of feeling. If we succeed in removing the systemic sensations the emotion

also disappears — it is reduced to a simple motor experience called *conation* (ch. xii). Most persons are able to control their motor expressions more readily than their organic processes. This is why the motor factor seems to be the crucial factor when we test emotions experimentally. We conclude, then, that neither the popular view nor the James-Lange theory is correct. Emotion is the joint product of nerve impulses from the systemic and motor senses. Emotional feeling and emotional expression are equally important parts of the experience.

The glands are even more important in emotion than in feeling. It is found that in some emotional conditions certain chemical products, such as adrenalin, are formed in great quantity and diffuse themselves among the neighboring organs. These compounds are apparently the stimuli which arouse the systemic elements in the emotion. Muscular contraction and muscular tension serve as stimuli for the motor elements.

Primitive Emotions. — Comparative studies on animals indicate that emotion is present in many species below man. This is particularly true of warm-blooded animals, including mammals and birds.[1] Their reactions and expressions correspond so closely to the manifestations of human emotion that we are justified in attributing real emotional experiences to these animals. The fundamental kinds of emotion may be studied to advantage in subhuman species, where they are not complicated by shadings which depend on thought and complex social relations.

In popular books the study of animal emotion consists too often in attributing to pet dogs and cats various shades of human emotion which depend on thought and reasoning. This reading of human experiences into lower species does

[1] In cold-blooded species the circulation is sluggish and there is not that quickening and violent agitation which is characteristic of human emotion. Their emotions, if they have any, are essentially different from ours.

not help us to understand the actual facts. The mental processes of subhuman species are far simpler than in man. The emotional display in the dog or cat is not the result of thought — it occurs without thought or reasoning; it shows, rather, to what extent emotion is independent of thought and more primitive than thought. What will help us, is to study carefully the manifestations of emotions in various animal species and *read them into man.* When a cat struts away from a growling dog with an air of offended dignity she has a pride *emotion* of some sort, but no *thought* of dignity. The inciting cause of the emotion is a perception, not an idea. This suggests that even in man the pride emotion depends perhaps more on perceptions and less on ideas than is generally supposed.

This method of studying emotion is helpful, but the conclusions should not be carried too far. Human emotion differs from animal emotion in the prominent part which memories and thoughts play in producing it. A child cries when we scowl at him, or exhibits fear at the sight of a snake or some other strange creature. His emotion is aroused by a perception, like the anger of the bull at the sight of red. But in the human adult, emotions are determined by ideas rather than by perceptions. We are angry when we see a big boy beating a small boy; we are not angry when we see a strong man beating a rug.

The most primitive emotions in man are those based on certain fundamental conditions of life, which led to the evolution of certain types of reaction in animals long before the human species appeared. The three most fundamental types of emotion are *fear*, *anger*, and *love*.

The feeling tone of *fear* is unpleasantness, which is usually very intense. The organic sensations which form part of the fear experiences are stimulated through receptors in the lower viscera and in the region of the lungs and heart. The characteristic motor expressions of fear are certain definite mus-

cular contractions, which produce trembling, shrinking movements, raising of the eyebrows, etc. These motor activities furnish muscle sensations which form an important part of the emotional experience.

In *anger* the feeling tone is also unpleasant, but the feeling tone is not so prominent as in fear. The special systemic sensations are derived from the upper digestive tract, the heart and lungs, and the circulatory system. An outburst of anger is accompanied by vigorous heart activity and breathing, which usually causes intense flushing of the face and sometimes a choking sensation and suffusion of the eyes. The characteristic motor activities of anger are clenching of the fists and teeth, strained tension of the face muscles, and rigidity of the lower limbs. These motor activities are accompanied by very intense muscle sensations. The expression of anger is generally movement *toward* the object — in fear the movement is *away from* its object.

Love is the third type of primitive emotion. Its characteristic feeling tone is pleasantness. The special systemic sensations are less prominent than in fear or anger; they arise from the region of the lungs and from the generative organs. The popular notion which associates the emotion of love with the heart is not so far wrong; careful observation shows that the characteristic sensation is located somewhat *above* the heart, but that it is due to the circulation and not to breathing. There are various motor accompaniments of this emotion, and the muscle sensations which these arouse enter prominently into the experience. A somewhat less intense variety of this emotion is *sympathy*. Here the general feeling tone (pleasantness) is most prominent, and the special systemic sensations are less definite than in love. The motor expressions of sympathy and love are generally movement *toward* the object. In sympathy a common form of expression is activity of the tear glands.

This is the way the psychologist describes the three great

emotions of life. It sounds very different from the description of the poet or story-teller. The psychologist and the poet have something quite different in view. The poet uses language which will thrill his readers and arouse the *same* emotions in them. The psychologist tries to show what sensations make up the emotional experience. It is like the attitude of the cook and the chemist toward the soup. The cook wants to make a soup that will tickle the palate; the chemist wants to know what is in the soup. Most men would prefer to see love through the poet's eye and fear or anger through the psychologist's.

Kinds of Emotion in Man. — Human emotions have been classified in various ways according as one characteristic or another is selected as the starting-point. The objection to most classifications is that they try to show all possible varieties instead of those that are really significant. Some types of emotion have developed tremendously and show many different shades, while others that we might expect to find scarcely appear at all. We can only discover what are the really important emotions in human life by actual observation and experiment.

An important aid in this study is to notice the various names used to distinguish emotions in the languages of civilized and uncivilized races. If a large number of different names for a certain kind of emotion are found in a given language, we infer that a great many shades of that emotion are present in the race using that language.

The list of emotions in Table VIII is based on the different kinds of behavior that man exhibits with reference to his surroundings.[1] For our present purpose five great classes of responses may be distinguished: nutritive, reproductive, defensive, aggressive, and social.

Strictly speaking, the nutritive functions do not lead to emotions: eating and its various accompaniments are usually

[1] See ch. x, p. 237.

TABLE VIII. — HUMAN EMOTIONS

1. *Expressive (Nutritive)*

Emotion	*Expression*
+Joy (Enthusiasm)	Diffused
−Grief (Despair)	"
−Shock	"
+Mirth	"
+Ecstasy	"
Restiveness	"
Exuberance	Play
+Wonder	Curiosity

2. *Reproductive*

Emotion	*Expression*
+Love	Mating
+Lust	"
−Jealousy	"
−Coyness	" (*female*)
+Tenderness	Maternal

3. *Defensive*

−Fear	Flight and Hiding
−Disgust	Avoiding
−Timidity (Embarrassment)	Shyness
−Shame	Covering
+Awe	Submission

4. *Aggressive*

−Anger (Rage)	Fighting
−Hatred	Resenting
−Envy	Rivalry
+Pride	Domineering
+Exultation	"

5. *Social*

+Affection	Family relations
+Cordiality	Herding
−Pity	Sympathetic
+Gratitude	"
+Admiration	"
−Detestation	Antipathetic
−Revenge	"
−Suspicion	"
−Scorn	"

6. *With Temporal Projection*

Retrospective Reference:

−Regret (Remorse)
+Satisfaction (Elation)
Surprise

Prospective Reference:

+Hope
−Dread
Anxiety

unemotional acts. But there are certain *expressive* emotions of an indefinite or diffused sort which depend indirectly on the nutritive life. Joy, grief, and the like are expressive emotions, made up of diffused feelings.

The defensive, aggressive, and reproductive emotions are represented by the emotions of fear, anger, and love, which we have already examined. These are the original forms; the table shows a number of other well-known emotions that have developed out of them.

The social life of man in relation to his fellows develops special emotions. Some social emotions are defensive or aggressive, but others do not belong in either of these groups. The fifth class in the table includes the social emotions that are not connected with other sorts of behavior.

There are also emotions that are essentially connected with ideas of the past or the future. The prospective emotion of *hope*, and the retrospective emotion of *satisfaction* are similar to *joy* apart from the time reference.

In the table the kind of feeling tone that is characteristic of each emotion is shown at the left and the kind of motor expression at the right. In most emotions the feeling tone is definitely pleasant (+) or unpleasant (−). Certain sorts, such as *restiveness* and *surprise*, may be either pleasant or unpleasant. Frequently they alternate between one quality and the other.

In many cases we may readily notice several different shades of emotion under the same general type. It is easy to distinguish, for example, between *anger* and *rage*. Some of these varieties are of considerable importance in mental life; *remorse*, for example, has very different consequences from *regret*. Some of the less important distinctions are interesting to study. Notice the difference between 'feeling slighted,' 'pique,' 'feeling insulted,' 'feeling outraged'; or between various degrees of mirth.

Adapting Emotions to Civilized Life. — The emotional life has not kept pace with the other phases of mental evolution. Perception, memory, and other types of experience have adapted themselves to changing conditions, but our emotional experiences continue in almost primitive form. Many of the more important emotions seem like echoes of our prehuman ancestors; they do not fit into the social life of to-day.

The emotion of anger is well adapted to the food-getting activities of carnivorous animals. It stimulates them to

greater exertions and seems really to help them in overcoming their prey. Even in primitive man strength is more important than skill. But under modern conditions of civilized life intellectual adjustment and motor coördination are far more valuable than mere strength. A Foch or a Hindenburg is the brains of the army, not its fist. The man who gives way to blind rage in the presence of an adversary is usually at a disadvantage. We look upon unbridled emotion of any sort as childish or brutish; one who has not learned to control the display of emotion is held more or less in contempt. People are even apt to regard the shell-shocked veteran as a coward, though really his disability should arouse the same feeling as the loss of a leg in battle.

Since our emotional inheritance is unsuitable to present conditions, the obvious course is to direct this phase of mental life into more suitable paths by systematic training. This is one of the most important tasks of education, socially speaking. Emotional training is not so prominent a feature of our present-day educational systems as intellectual training; it is generally accomplished indirectly or incidentally. School discipline and home discipline, especially through punishment and admonition, teach the child to repress or suppress violent displays of emotion. Social tradition and example help considerably. The child finds that he makes himself ridiculous by giving free vent to his emotions. The 'cry-baby' is an object of contempt among children; the stolid child or youth is admired by his playmates.

The ideal of a calm, passionless life may perhaps be socially desirable, but it does not take into account the innate propensities of the individual. No boiler is strong enough to resist every pressure, and the engineer who clamps down the safety-valve is heedless of the best interests of his machine. Expression is the safety-valve of emotion. The emotional tendencies are part of our mental inheritance. It is not possible to eradicate them entirely. Freud has shown that

the struggle to suppress them often results in nervous disorganization. On the moral side it fosters deceit and hypocrisy. A rational training of the emotions would consist in modifying their feeling elements and directing their motor expression into useful channels.

The various classes of emotions differ considerably in value. The defensive emotions refer back to prehistoric modes of defense, and for the most part hamper us under modern conditions. The same is true of the aggressive emotions. On the other hand, the social emotions harmonize well with modern social conditions, excepting those which are distinctly antipathetic. The reproductive emotions (especially love and tenderness) are by no means anachronistic, but they require careful training to fit them into the social life of civilized man. In some communities this training has gone to extreme lengths.

The expressive emotions and the retrospective and prospective types are socially neutral. Extreme manifestations of joy, grief, mirth, regret, hope, and the like, do not fit in with modern life; but a moderate display of these emotions is not socially detrimental and is of some benefit to the biological life of the individual.

In short, psychology and pedagogy should recognize that the emotional side of our mental life is to some extent behind the times. Uncontrolled emotion hampers the proper interaction between the individual of to-day and his environment. It is only when our primitive, inherited emotions are trained into socially acceptable modes of expression that this phase of mental life is brought into harmony with the rest of our experiences and actions.

SENTIMENT

Nature of Sentiment. — Besides feeling and emotion, there is another, less important experience connected with our inner bodily processes, called *sentiment*. A sentiment is

an experience which is made up of systemic sensations and ideas.[1]

Sentiments may be aroused by any external sensation or idea, but the experience itself is essentially different from either. Your "sense of beauty" is not a sensation nor a perception, but a sentiment. It may be aroused by seeing the Venus de Milo, or by listening to Beethoven's Fifth Symphony, or by the memory of one of these experiences; but the sentiment of beauty is not the perception of the object. The perception suggests the sentiment, and then fades into the background of the new experience. The prominent elements in the sentiment of beauty are a *feeling* and an *idea of value* (ch. xiii).

When something has aroused a sentiment, and the same situation continues to affect us, we connect the sentiment with the perception and read it into the objective situation. The statue 'looks beautiful.' The world about us 'looks real.' A locomotive appears powerful. An action appears good.

Are the beauty, reality, and power in the objects themselves? Is the 'goodness' in the action or in the actor? In discussing feeling we noticed that pain is not a quality of the sharp knife, though we experience pain when the knife cuts us, and the pain is stimulated by the sharp edge. In much the same way the sentiment of beauty is stimulated by certain combinations of tones in music or by certain curves or color combinations in a painting; but it is not a quality of the music or painting. And the same is true of power and goodness. Our sentiments are generated within us; they are intimately personal, like pain, and yet they are excited by something in the external stimulus.

[1] The term *sentiment* has a special meaning in psychology. It is not precisely what we mean by 'a sentiment' in ordinary language, and it does not correspond to the adjective 'sentimental'; but it carries a trace of each notion — the imagery of 'a sentiment' and the feeling tone of 'sentimental.'

Kinds of Sentiments. — Sentiments are classified according to the kind of experience that arouses them. [Table IX.]

TABLE IX.— CLASSIFICATION OF SENTIMENTS

Sentiments	*Source*
Reality Feelings	Perceptions
Beliefs	Ideas
Esthetic Sentiments	Systemic Experiences
Dynamic Sentiments	Motor Experiences
Moral Sentiments	Social Situations

The sentiment of realness, or *reality feeling*, attaches to perceptions of the outer world. We are *sure* that the objects which we see, palp, heft, hear, etc., really exist. Usually this sureness or conviction is marginal. Like the familiarity feeling, it is only a subordinate element in the perception. In adult life the reality feeling rarely occurs as an independent experience. It takes something unexpected, or something that does not fit in with our general scheme of things to bring it out vividly. If we meet a friend who was supposed to be a thousand miles away, the reality of his presence bursts through into prominence. The other extreme occurs in day-dreaming, or when we are dazed by a sudden blow or a loud noise: then the reality element is quite lacking — things about us do not impress us as real. In certain pathological conditions the sense of reality disappears completely: the patient declares that the world does not seem real.

Belief is very much like reality feeling, except that it is associated with ideas. We are sure that certain of our images and thoughts are true. Two opposite varieties of belief have developed: affirmative belief, and negative belief or disbelief. We may either believe in the existence of the object we are thinking of; or we may believe that no such object exists. When you picture a mermaid, your sentiment is belief in its falsity, while if you have a mental picture of Vesuvius the sentiment takes the form of belief that this volcano actually exists. In the two cases the sentiment is of the same type —

belief — but our *attitude* is different (ch. xv). The 'not' attitude gives a special tinge to the sentiment. The true opposite of belief is not disbelief, but *doubt.* Doubt is a sentiment which arises from alternation of belief and disbelief.

Esthetic sentiments arise when the feeling tone of an experience is especially intense and combines with an idea of value. This produces a sentiment of *beauty* or *harmony* if the feeling is pleasant, and a sentiment of *ugliness* or *discord* if the feeling is unpleasant. The intensity of the esthetic sentiments varies considerably with the individual and with training. In some persons an appreciation of beauty and harmony appears early in life and develops without any special training; in others it is only attained gradually, through education and imitation. Esthetic sentiments are especially characteristic of the 'artistic' type of personality.

Dynamic sentiments arise when vivid motor sensations are associated with our perceptions. These motor sensations are stimulated by the activity of our own muscles; but their intensity depends upon the weight or resistance of objects that we try to move. In connection with our voluntary movements there is a sense of *power* or *ability to act.* If the resistance is strong, we have a sense of *opposition*, of *being thwarted*, of *force or power in the environment.* These are dynamic sentiments. A tornado, a great factory machine in action, arouse a sentiment of the power of inanimate nature. The religious sentiment is due to an idea of some mighty power in the universe. Dynamic and esthetic sentiments combine to form the sentiment of the *sublime.*

Moral sentiments come from feelings which attach to our perceptions of social acts — usually the actions of other persons. The 'traffic cop' who goes over and leads a blind man across the street arouses your approval; the youngster who hurls a stone through a shop window arouses a feeling of disapproval. In each instance the feeling combined with the

idea of social value forms a moral sentiment,— in one case a sentiment of *right*, in the other a sentiment of *wrong*.

Sentiments are the least important kind of experience. If a sentiment is weak it becomes an element in some other state of mind. If it grows intense, it tends to bring about some motor expression; this arouses muscle sensations and the experience is no longer a mere sentiment. Esthetic sentiments pass readily into emotions; dynamic sentiments arouse an impulse to overcome resistance or to exert our own power. Moral sentiments, if they are vivid, are likely to pass over into voluntary actions. We are not content with merely condemning or approving the actions of others. If a wrong appeals to us deeply, we are apt to start in to remedy it. We 'push along' a good thing — literally as well as figuratively.

In a word, sentiments lack stable equilibrium; if they are weak they are crowded out of focus by other experiences; if they are intense this very strength transforms them into something else. Beliefs are the most stable of all sentiments. Our belief in the multiplication table and other fundamental truths persists unaltered throughout life. Other underlying beliefs undergo certain changes from time to time, but still remain as enduring sentiments.

Summary. — In this chapter we have examined three sorts of experience in which systemic sensations are prominent. *Feelings* are experiences consisting almost wholly of (1) organic sensations — that is, sensations from the internal organs of digestion, reproduction, circulation, respiration, and other bodily processes, — or (2) pain sensations, or (3) feeling tone and general sensibility. Feelings are experiences of our own bodily condition, and may be contrasted with perceptions, which are experiences of the outer world.

Emotions are experiences in which both systemic and motor sensations are prominent. They combine feeling and action. In general they are more intense and vivid than simple feelings and occupy a specially prominent place in mental life.

Emotional experiences belong to primitive conditions of life and do not fit in especially well with man's higher mental evolution.

Sentiments are experiences which combine systemic sensations with ideas. They are generally weak and unimportant in mental life. Belief is the most hardy of all the sentiments. The others tend to fade into the background, or they lead to action and so are transformed into some other kind of experience.

PRACTICAL EXERCISES:

44. Analyze your general state of feeling at three different times; e.g. on waking, after a hearty meal, after a brisk walk.
45. Describe the expression of three different emotions, in cases you have witnessed recently.
46. Analyze some powerful emotion of your own at the time or soon after the outburst has subsided.
47. Mention some fact which you believe thoroughly; also some statement which you are sure is false; also something about which you are in real doubt. Now examine the sentiment you have in each case — the belief, the disbelief, and the doubt; describe them as far as possible.
48. Describe the expression of anger (or fear) in a child.

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On the physiology of emotions: C. W. Crile, *Origin and Nature of the Emotions*; W. B. Cannon, *Bodily Changes in Pain, Hunger, Fear and Rage*.

CHAPTER X

INSTINCT

Motor Experiences and Response. — The experiences so far examined belong to two separate groups: (1) Perceptions, memories, and their kindred are based on the information we receive from the outer world. (2) Feelings and emotions are concerned with internal conditions and are stimulated by the physiological processes which go on within our own body. There is still a third class called *motor experiences*, which are composed largely of motor sensations. The muscle sense and static sense furnish information about our movements and responses, and about our bodily postures with reference to the outer world. These sensations are organized into experiences called *conations*, and when joined to images and thoughts they develop into secondary experiences called *volitions* and *language*.

Motor experiences differ from other experiences in one important respect: We perceive, we imagine, we feel, *before* we act. Motor experiences, on the other hand, are the result of our motor activity; they arise *after* the motor nerve impulses have begun to affect our muscles. When we walk, we sense each movement of our limbs as it takes place. In other words, whereas perceptions, images, and feelings keep us in touch with the *stimuli* that affect us, conations and other motor experiences are concerned chiefly with our *responses*. Before taking up these motor experiences,[1] we must examine the motor side of the nervous operation and see how it is related to stimulation.

Every stimulus starts an impulse in the sensory nerves, which proceeds to some center in the spinal cord or brain.

[1] See chs. xii, xiii.

In these central neurons there is a certain amount of latent nerve energy, so that the incoming impulses, instead of being 'absorbed,' actually *arouse a greater amount of nervous activity* at the centers, and this activity seeks an outlet into other neurons. The nervous activity aroused in the brain by visual stimuli results first in our perceiving the scenes around us, and this perception may be followed by a series of memories and fancies. But this succession of events in the brain does not continue indefinitely. In the end the central impulse finds an outlet into some motor path and passes out of the brain and down to some muscle, where its energy is expended in producing muscular contraction. The final result of the nerve impulse in this case is *movement*. In other cases the outlet is into a path leading to some gland, and the final result is the chemical process of *secretion*. Our notion of nervous activity will be incomplete, then, if we stop at the central processes of perception, feeling, and the like. *Every stimulus tends in the end to bring about some response.* The most significant feature of the entire nervous and mental process is not the information it furnishes, but the way we *act* upon this information. Action by a creature in response to stimulation is called *behavior*.

Kinds of Behavior. — Behavior may be grouped into the following classes:

Diffused movements
Reflexes
Autonomic functions
Instinctive behavior
Intelligent behavior

(1) Diffused Movements: Nerve impulses always follow the path of least resistance. If the neurons were not arranged in definite groups and chains, the nerve impulses might follow all sorts of paths and our responses would be largely a matter of chance. The same stimulus would lead now to this movement, now to that, at random, without any appropriateness

whatever. Impulses would tend to spread into several channels at once and cause diffused movements.

Diffused movements occur in the new-born child. When he is affected at the same time by several stimuli none of which is especially intense, his responses are uncoördinated; they bear no significant relation to the stimuli. Observe a child lying on his back when nothing in particular is affecting him. He wriggles his arms, gurgles, winks, kicks about, moves his toes, his lips, his eyes, his head. These diffused random movements are the result of general stimulation by light, pressure, warmth, and sounds. The incoming impulses are weak and diffused; they find outlets here and there through various motor channels.

(2) Reflexes: Diffused response is not the only form of behavior in the new-born child. Our nervous system is arranged at the start *by heredity* in an orderly way. The sensory and motor centers are placed in very definite relations to one another. From the very beginning certain sensory paths are closely connected with certain motor paths, so that stimuli which affect a given receptor are bound to bring about certain definite responses. If an infant's palm is touched with a stick he grasps it; if a milk bottle is put to his mouth his lips close around it; certain stimuli produce coughing, others produce sneezing. These are immediate responses, brought about by inherited connections between sensory and motor nerve paths. A definite response to a definite stimulus, due to an inherited arrangement of the nerve paths, is called a *reflex*, or *reflex action*.

(3) Autonomic Functions: The earliest reflexes that occur in a child's life are due to systemic stimuli. Long before birth the heart begins to beat through stimuli which arouse activity of the heart muscles. Immediately after birth the lungs are stimulated and the result is muscular activity which draws the air into the lungs and expels it again. These responses, which control the bodily processes of circulation and respira-

tion, are so arranged that each response furnishes a stimulus for another reflex of the same sort. They form a chain of reflexes, which continue in endless series during the entire life of the individual. Regardless of the environment (except in a general way), the lungs expand and contract, the heart pumps blood into the arteries continuously till death.

These chains of reflexes which govern the life processes are called *autonomic functions*. They are of the utmost importance to life; but since they are only indirectly concerned with the individual's relations to his environment, they do not interest psychologists especially. Their special bearing on psychology lies in the fact that the autonomic nervous system is connected with the main cerebrospinal nervous system (ch. ii). By reason of this connection the autonomic functions may be modified by motor impulses from the brain and spinal centers. This occurs, for example, in voluntary changes of respiration and in the changes in heart activity that accompany the emotions.

The digestive processes are controlled by the autonomic system also. But they do not form a single continuous series of reflexes like respiration and circulation. Digestion depends upon stimulation by food in the stomach or intestines; in the absence of food the digestive organs are comparatively inactive. When food is taken into the mouth the digestive organs are stimulated and the autonomic processes begin to act at once; they include a whole series of digestive activities ending in the excretion of the waste products. All these processes are subject to some control by the cerebrospinal system, and often serve to stimulate and modify its activities. Apart from this connection, psychology is not particularly concerned with the autonomic functions.

(4) INSTINCTIVE BEHAVIOR: The nervous connections within the cerebrospinal system are not so close as those of the autonomic nerves. There is more branching of neurons and consequently more possibility of alternative motor dis-

charges. But the various nerve paths and centers are so arranged by inheritance that certain connections are *inevitable*, especially in early life. Not only are there from the beginning certain definite reflexes to external stimulation, but some of these reflexes cause stimuli which produce other reflexes, so that when a given stimulus occurs a definite chain of reflexes inevitably follows. This is best illustrated in the feeding activity of the infant. The contact of the lips with the breast or bottle causes the *lip-grasping* reflex. This serves as stimulus to the *sucking* reflex. The milk in turn stimulates the *swallowing* reflex. Any succession of cerebrospinal reflexes like this, in which one response provides the stimulus for the next, is called an instinct, or *instinctive behavior*.

In subhuman species, where the branching connections are not so numerous as in man, a large part of behavior is of the instinctive type. Remember that in any instinctive act the successive steps follow in natural order — each is caused by the preceding. There is no delay; no thinking and deciding what to do. The progress of the action is automatic [1] unless checked by some interfering stimulus. Instinctive behavior generally brings about some result that is useful to the creature; that is, it is *adaptive*. This is because the nervous structure, like the rest of the body, has grown up in the course of long ages of time through the natural selection of useful arrangements of the neurons and centers.

(5) INTELLIGENT BEHAVIOR: The branching connections in the nervous system make possible still another type of behavior. Reflexes that are not so closely connected as to form instincts, may come in time to be grouped into hard and fast series of actions which are of the utmost importance to life. A series of useful movements whose connection is not based on heredity, but is acquired by the individual, is called *intelligent behavior*. If the act becomes so fixed that it proceeds as

[1] Not to be confused with *autonomic*.

automatically as an instinct, it is called a *habit*. Speaking and writing are instances of human habits.

The human adult finds it difficult to draw a sharp line between instinctive and intelligent behavior in the case of his own actions. Early in life our instincts begin to be modified, and these new modes of action are often so quick and automatic that they seem to be inborn. Most of our actions have marked instinctive elements and equally marked intelligent elements. Walking is especially hard to classify. When the child starts to walk his movements are uncertain, and they seem to improve by practice; but the fact that walking always develops at about the same age indicates that it depends fundamentally on certain inherited factors. On the whole the act of walking seems to be mainly instinctive in man.

Reflex Behavior

Nature of the Reflex. — The *reflex* is the simplest form of response in creatures possessing a nervous system. It involves the operation of a single nervous arc or a number of arcs acting together.

The characteristic feature of reflex activity is that the response is *definite*, not diffuse. This makes it a suitable type of activity for response. It *accomplishes something*. The infant's diffuse movements are responses to stimulation, but they are not especially adaptive — they do not answer the problems which the stimuli set before the child. Definite reactions of the reflex type do this. Winking protects the eyes; swallowing assists the nourishment process. Even glandular reflexes may solve some of the minor problems of life, — weeping may remove a cinder from the eye.

While reflex activity is definite, it is by no means invariable: the response usually varies with the intensity of the stimulus. Very intense stimulation generally causes violent muscular contraction, and the effect is apt to be widespread. The shudder reflex extends over a larger part of the body when the

stimulus is more intense. The tickle reflex is an exception to this rule: the tickle stimulus is less intense than the ordinary touch stimulation, but its peculiar quality brings about a much more violent response than ordinary contact.

Varieties of Reflex Action. — In reflex action the stimulus starts a nerve impulse along the sensory nerve toward the central part of the nervous system; at the center the impulse passes over to a motor path and descends to a muscle or gland, causing responsive activity. This process may be complicated in two ways: (1) The impulse may either cross to the motor path and pass out at the first opportunity; or it may proceed to a higher center and then pass out. On this basis reflexes are divided into *lower* and *higher*. (2) The sensory impulse may produce a single response; or the motor impulse may divide and go out to two or more effectors at once. On this basis we distinguish between *simple* and *compound* reflexes.

In *lower reflexes* the adjustment takes place in the spinal cord or in the lower centers of the brain. When you touch a hot stove, the sensory impulse upon reaching the spinal cord immediately passes over to the motor side and a motor impulse goes out directly to the hand, so that you withdraw the hand before you feel the heat or pain.

In *higher reflexes* the sensory impulse travels to a higher brain center and the adjustment takes place there. A sudden loud noise often produces violent beating of the heart. The sensory impulse goes first to the primary center of hearing, then to a higher center, and from there part of the impulses passes out through a motor pathway to the cardiac muscles.

A *simple reflex* involves a single nervous arc; the sensory impulses all travel up through a single sensory nerve and the outgoing impulses all proceed along one motor nerve and affect a single muscle.[1] When we hear a sound and auto-

[1] A number of *parallel neurons* in the nerve usually carry the impulse inward or outward.

matically turn the eyes in that direction, the action is a simple reflex. [Fig. 71; cf. Fig. 16, p. 41.]

A *compound reflex* involves two or more separate motor nerves. The hand-grasping reflex is a compound reflex,

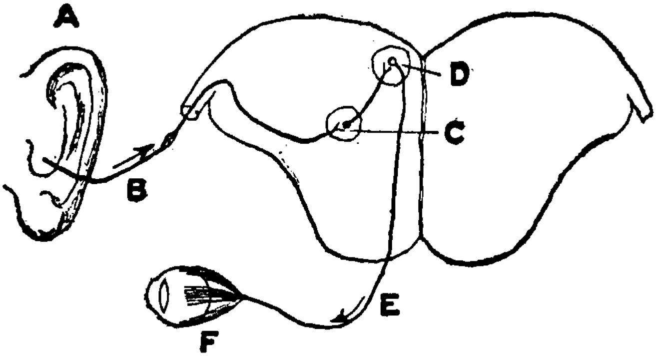

FIG. 71. — SIMPLE REFLEX

Simple cranial reflex from the ear to the eye muscles. A sound stimulates the ear (A) and starts a sensory nerve impulse along the 8th cranial nerve to lower auditory center (C) in the brain. The impulse travels to the center for eye movement (D). Thence a motor impulse passes along the 6th cranial nerve (E) to the eye muscles (F); the muscles contract and the eye is turned toward the sound. (A simple *spinal* reflex is shown in Fig. 16.) [After Herrick.]

because it involves the muscles of all the fingers and several joints in each finger.

In nearly all reflex actions there is a certain compounding of impulses in the sensory part of the nervous arc. The eye-wink is a response to stimulation of the whole field of vision, or at least a large area; the withdrawal of the hand from a hot surface is usually in response to a temperature stimulus that affects many warmth receptors covering quite an area of the skin. This compounding of sensory impulses is not especially significant; it serves to intensify the response, but seldom changes its character.

The simplest sort of compounding occurs in reflexes which have two or more motor effects. This is called a *distributed* reflex, because the outgoing impulse is distributed into

several motor paths. The operation of a distributed reflex is shown in Fig. 72. This diagram represents what happens, for example, in the pain reflex.

A simple reflex may form part of a distributed reflex. For example, in the knee-jerk, when the nerve impulse reaches the cord it may divide; a portion may cross over directly into the cord or the motor path and cause the leg to fly up, while part may travel up to the brain and produce some other type of activity, such as grunting or flinching.

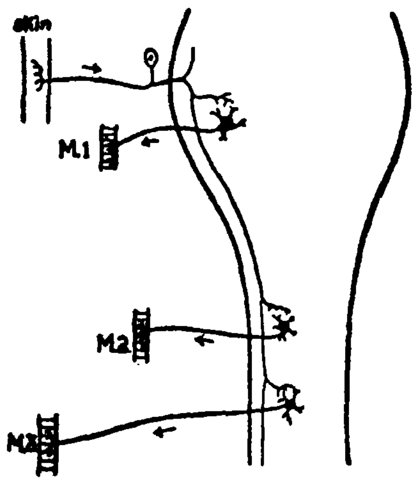

FIG. 72. — DISTRIBUTED REFLEX

Showing how stimulation of a receptor in the skin leads to contraction of several different muscles M1, M2, M3. [From Herrick.]

If the entire impulse reaches a higher center it may result in a *coördinated* compound reflex. Grasping, sucking, and certain vocal reflexes are examples of this. In the grasping reflex of the hand all the fingers are bent at once; the sucking reflex sends motor impulses to several different muscles in the lips, cheeks, and tongue. If the higher centers come into play the response may be on the opposite side of the body from the stimulus; frequently it is bilateral. This is due to the fact that the motor pathways to the two sides of the body are connected by transverse paths in the brain.

Among compound reflexes considerable importance attaches to the way in which the different muscles are related. We distinguish between *antagonistic* reflexes, in which the impulses lead to opposing or antagonistic muscles, and *allied* reflexes, where the various muscles assist one another. In

TABLE X.—HUMAN REFLEXES

A. Purest — least subject to central modification in adult

'Pupillary' or iris reflex	Shuddering
Ear twitching (controlled in some individuals)	Starting (to sudden noise, etc.)
Hand withdrawal (to heat and pain)	Shivering
Digestive reflexes (autonomic)	Trembling
	Rhythmic contractions (in epilepsy, paralysis agitans, etc.)

B. Largely pure — subject to inhibition or reinforcement

Winking	Hand twitching (to dermal pain)
Accommodation, ciliary reflex	Plantar reflex (to stimulus on sole of foot)
Eye-fixation and convergence	Great toe reflex
Hiccoughing	Vasomotor changes (blushing, paling)
Sneezing	Breathing changes (to specific stimuli and to onset of sleep)
Patellar reflex (knee-jerk)	Sudorific reflexes
Dizziness reflexes	Groaning
Yawning	Laughing
Vomiting	Cramp movements
Facial reflexes (to bitter taste, etc.)	Squirming
Salivation	
Tickle reflexes	

C. Occasionally pure, more often centrally modified

Coughing	Smiling
Swallowing and gulping	Wincing, etc.
Visceral discharge, etc.	Scowling
Generative reflexes	Stretching
Reflexes to odors	Convulsive contractions (to deep pressure and heat, to pricking and other dermal pains, and to visceral pain)
Gasping	
Weeping	
Sobbing	

D. Pure in infancy, centrally modified in adult

Sucking	Tugging (wrist reflexes)
Biting and grinding	Clasping (elbow reflexes)
Spitting	Reaching (shoulder reflexes)
Hunger and thirst reflexes	Kicking (knee reflexes)
Lip and tongue reflexes	Stepping (gluteal reflexes)
Vocal reflexes	Jumping (ankle reflexes)
Turning the head	Sitting up
Tossing	Bending forward
Grasping (finger reflexes)	Rising

E. Posture reflexes

Holding head erect	Standing
Sitting	Equilibration

some cases the actions of different muscles tend partly to neutralize, partly to reinforce one another; these are called *allied and antagonistic* reflexes. Where several reflexes follow in succession, they may be *alternating*, as the two legs in walking, or *supplementary*, as the flexing of the several finger joints in grasping.

These relations emphasize the fact that a reflex is not a mere muscular contraction; it is a *response* to the stimulus — it accomplishes something. An isolated reflex, such as the knee-jerk, may not be particularly useful; but compound reflexes generally tend to bring about some result which makes life a bit easier.

Human Reflexes. — In human adults comparatively few activities belong to the pure reflex type. Even such a reflex as winking may be reinforced or partly inhibited by voluntary control; and the same motor paths that carry impulses for the winking reflex also carry impulses for voluntary winking and for closing the eye.

Table X shows the most important human reflexes that have received familiar names. There are many others with technical Latin names which involve single muscles or whose connections are somewhat obscure. In some cases a number of similar reflexes have been grouped together under one name in the Table (e.g., the facial reflexes). The list is chiefly interesting as showing the great variety of comparatively simple motor activities, and how much more voluntary control we have acquired over some than over others.

Instinctive Behavior

Nature of Instinct. — The term *instinct* has been variously defined. Earlier writers treated it as a mysterious innate power possessed by subhuman animals, which enables them to do the right thing in the right way, without consciousness or deliberation. This notion still prevails in popular psychology. To-day we know that instinctive behavior is the result

of integration and coördination of nerve impulses, and that this 'central adjustment' is due to inherited nervous connections.

Following out this notion, instinct is defined as any sort of complex behavior that involves a set of reflex activities, in which (*a*) one reflex furnishes the stimulus that leads to the next, and in which (*b*) the connections depend upon inherited structure, not upon gradual learning by the individual. In walking, for example, each movement serves as a stimulus for the next. When the *left* foot touches the ground the touch stimulus, together with the muscle-sense stimulus from the muscles of the left leg, starts the motor impulse for lifting the *right* leg, and so on. This succession of response and stimulation is characteristic of instinctive behavior generally.

In most instincts each act in the series involves a different kind of reflex from the preceding. A typical example is the suckling instinct in the human infant. This involves a succession of different reflexes: bending the head, grasping with the lips, sucking, and swallowing. Each reflex in the series furnishes a stimulus which causes the next reflex, as already pointed out.[1] In later life the series is broken up, but the last link in the chain still holds: when you take food into the mouth, especially if it reaches the back of the tongue, it stimulates your swallowing reflex so powerfully that you can scarcely avoid making the swallowing contractions.

Instinctive action takes place because each reflex that composes it follows an inherited path of least resistance, and because the motor response of one reflex provides the appropriate stimulus for the next. The development of an instinct may be thwarted if at any stage the movement does not lead to the proper stimulus for the next stage. As a general rule the same fundamental instincts appear in every individual of the species at about the same period of life, because they all

[1] P. 228.

inherit the same fundamental nerve structure and live in substantially the same environment.

Origin of New Instincts. — Every species of animal, mankind among the rest, has evolved certain typical kinds of instinctive behavior. Some instincts belong to a large number of species; others to a single species. The origin of widespread instincts and their special varieties is explained on the basis of natural selection in the following way:

Each separate reflex appears in the first place in connection with some *chance variation* of nerve structure. The variations that are useful to a species are *selected;* that is, because a given reflex is useful in keeping the creature alive, more and more individuals having this reflex live to maturity; those without it are at a disadvantage and die young.

The combination of reflexes into instincts is due to chance variations in the position of nerves, which bring certain pathways close together. Suppose some new combination of reflex paths, brought about by chance variation and capable of inheritance, is especially fitted to preserve the animal's life; then the creature possessing this new combination is more likely to survive and transmit the instinct to his offspring. Not every new combination is advantageous. If a variation should occur in the feeding instinct of such a sort that the sucking reflex was not stimulated by lip-grasping, the result would be disastrous to the infant: he would starve to death. Detrimental variations tend to weed themselves out by the very same selection that promotes the survival of advantageous variations.

Human Instincts. — The human adult seldom behaves in a purely instinctive way. His activities are largely modified and controlled by individual experiences. Even the deep, underlying instincts are partly suppressed and reduced to conventional forms. As we pass from infancy the feeding instinct is greatly modified by the use of our hands and various implements for eating. It ceases to be a pure instinct.

Many innate tendencies never get a chance to develop into instincts; they are modified by habits which are already formed when the tendency appears; so that what we get is a form of behavior that is partly instinctive, partly intelligent. The tendency to prefer the right hand over the left, for instance, does not appear till after the child has learned to use his hands in various ways. In later life it is difficult to say how much of our right-handedness is innate and how much is due to training.

There have been wide differences of opinion among psychologists as to the number of human instincts. James and others insist that man possesses a great variety of instincts — as many, in fact, as any of the lower species. Other writers restrict human instincts to a few kinds. Both views are partly correct. The human adult has few *pure* instincts, but he has a great number of *modified* instincts. When we speak of human instincts, it is to be understood that the behavior described is not wholly inherited, like most animal instincts, but only that it is *very largely determined* by inheritance. In this sense walking is a human instinct, though a child may be aided in developing it by teaching and imitation.

It is convenient to classify human instincts according to the kind of results they bring about. What objects in life do our various movements and actions accomplish? What purposes do they serve? Looking over the field broadly, we find that man tries to attain one or other of the following results by his activities:

Nutrition: maintenance of bodily organization
Reproduction: perpetuation of the species
Defense: prevention of injury by the environment
Aggression: destruction of enemies
Social organization: coöperation with his fellows
Individual development: his own improvement

Most of these great objectives in life give rise to emotional expression, as we noticed in the last chapter.[1] They are, in

[1] P. 214.

fact, the motives for all our complex actions, whether emotional or not; they determine both instinctive and intelligent behavior. These six kinds of biological purposes serve as a basis for classifying human instincts. Human beings, by their inherited nervous make-up, perform actions which result in their getting food, reproducing their kind, warding off destruction, overcoming their enemies, coöperating with other men, and improving their own condition.

TABLE XI.— HUMAN INSTINCTS

1. *Nutritive*	2. *Reproductive*
Walking	Mating (sexual attraction, courtship)
Feeding	Maternal
Wandering [Hunting]	Filial (of infancy)
Acquiring [Hoarding]	
Cleanliness	
Diffused expression	
3. *Defensive*	4. *Aggressive*
Fighting	Fighting
Submission	Resenting
Hiding	Domineering
Avoiding	Rivalry
Modesty [Shyness]	
Clothing [Covering]	
Constructing [Home-making]	
5. *Social*	6. *Individual Development*
Family (parental and filial)	Imitativeness
Tribal [Herding]	Playfulness
'Apopathetic'	Curiosity
Sympathetic	Dextrality (right-handedness)
Antipathetic	Communicativeness
Coöperative	Esthetic expression

[*Note:* Names in square brackets denote a more primitive form of the same instinct.]

The principal human instincts are shown in Table XI. Looking over the list we recognize many familiar kinds of actions which need no comment. The meaning of some of the others is not so clear. The *wandering* instinct, which to-day finds expression in exploration and globe-trotting, seems to be

derived from a more primitive *hunting* instinct; and the tendency to *acquire* property harks back to a *hoarding* instinct in the days when life depended on storing away supplies for the winter.

Often a single instinct includes several different kinds of behavior. For example, fighting may be performed with the fists or the feet — or even with the teeth. Part of this diversity of expression is due to the fact that our inherited tendency to fight is developed this way or that by intelligent learning. *Diffused expression* is the emotional display of general systemic conditions; it includes the natural expression of joy, grief, and the like. These diffused instinctive expressions are the only instincts in the nutritive group that are distinctly emotional.

The instincts belonging to the reproductive group develop somewhat later than the others, due to the slow maturing of the generative organs. Yet rudimentary expressions often appear at an early age. Symptoms of courtship are seen even in young children. *Filial* instincts determine the child's behavior toward his parents. A child may manifest the same devotion toward adopted parents; it is not a question of actual relationship, but of an instinctive tendency on the child's part to behave in certain ways toward those who foster him. After the fostering age is past, family ties rest more and more on a social basis.

The defensive and aggressive instincts are not always opposite alternatives, as one might suppose. Fighting and fleeing are alternative ways of responding to the same stimulus; but many defensive instincts have no counterpart in the aggressive group. The *covering* and *home-making* instincts in primitive man are instances of this; they arose because man needed protection from rain and cold. In civilized man these instincts have developed into *clothing* and *constructing* tendencies. The constructing instinct has had far-reaching results in the sphere of invention.

The *clothing* instinct and the *modesty* instinct are apt to be confused. If we trace them back to their primitive forms, covering and shyness, the distinction is more obvious. Shyness is connected with our personality; covering has to do with our body. In civilized life modesty is a defense measure against the attacks on our mental privacy, while clothing is a means of protecting the body.

In the list of social instincts are included only those forms of behavior that are essentially social — actions which are neither defensive nor aggressive but have to do chiefly with social organization. The family instincts are closely related to the mating instincts — tribal instincts only remotely so. Family life may exist without community life, as we find in many primitive races.

The instincts called *apopathetic* (for want of a better name) are responses to the attitudes of others. We tend to act differently when others are present, even though they pay no attention to us; the bare fact of their being around has an effect on our behavior. We respond in special ways to the approval of others, and in other special ways to their expressions of disapproval.

The distinction between *sympathetic* and *antipathetic* behavior is too obvious to need discussion. We see instances of each almost daily. The only question is whether this distinction is innate, or whether the two opposing types of behavior are acquired through social intercourse. There is reason to believe that the distinction rests on inheritance. Certain people please us from the start, and others are repugnant. In each case the person arouses a *feeling* in us. What stimulates this feeling? Usually some sensation — from sight, hearing, smell, etc. This man has an attractive face or manner; that man's voice pleases us. The external senses may also arouse dislike — consciously or subconsciously. The scarcely perceptible human body odor often arouses an indefinable antipathy; race antagonisms are probably due to this cause.

The *coöperative* instincts are similar to the tribal instincts. Division of labor to produce 'community results' is instinctive in the ants, where certain classes of individuals perform various duties. In man coöperation is largely an acquired trait; but it probably rests upon an instinctive basis.

Instinctive Tendencies. — The types of behavior connected with individual development (Table XI) are not instinctive responses, strictly speaking: they do not represent *definite ways of acting*. *Imitation*, for instance, may be observed in any one of a hundred different actions; an action is imitative if it reproduces some other person's act, or if it brings about a result which resembles some other result. Generally the ability to imitate anything is acquired by a process of learning — it is not inherited. But there are distinct inherited paths in the nervous system which enable us to *try* to imitate, instead of responding in some entirely different way. An inherited *tendency to imitate* is found in some subhuman species; the parrot tends to imitate speech and the monkey to imitate gestures. But the parrot has no arrangement of nerve paths for reproducing gestures, nor the monkey for reproducing articulate expression.

Imitation, then, is not an instinct; but there is in certain species an *instinctive tendency* to imitate.[1] The same is true of play and curiosity. They are definite inherited tendencies, which find expression in various sorts of acts. The actions themselves are not inherited, but they are learned more quickly on account of the innate tendency.

The *imitative* tendency is much stronger and more extensive in man than in any other species. This is due to the vast system of connections between the various centers in the human brain. We are able to imitate not only vocal expressions (like the parrot) and gestures (like the monkey), but muscular movements of almost every sort which we see others perform. We copy handwriting, where we see only the result

[1] The tendency is *imitativeness;* the act is *imitation.*

and not the movements made in writing: we can reproduce the form of objects in nature by gestures or by drawing. Often the imitation succeeds only after a more or less elaborate course of training; but the *tendency* to imitate is inherited; it is based on man's nervous make-up.

Play is partly an imitative phenomenon. Children learn to play games by imitating other children; when they play at being grown up, they imitate (often grotesquely) the actions of older people. But the play behavior has also a distinctive character of its own; play means a tendency to perform acts which are not directly concerned with our bodily or mental welfare, but which serve as an outlet for our nervous energy. This is characteristic of all play, whether imitative or spontaneous, social or solitary. Such widely different activities as 'playing telephone,' the game of football, a solitary game of cards, a ramble in the woods, have one common feature: they represent *relaxation* from the serious business of life.

Curiosity is the innate tendency to seek information. It is a deep-rooted human trait, and distinguishes man from other species. The curiosity of dogs and other animals is probably merely involuntary attention to very vivid stimuli. The dog is not curious to explore the burrow in the ground; he is held there by the odor which indicates the presence of a rabbit. Curiosity manifests itself in mankind in a variety of ways, which differ according to the individual's tastes and habits of life. It may take the form of exploration, study of nature, delving into history, listening to gossip, and other kinds of behavior.

Right-handedness, more properly called *dextrality*, is the preference of one hand over the other in performing acts; in a majority of cases the right hand is preferred (dextro-dextrality), though in many individuals it is the left (sinistro-dextrality). The tendency is supposed to rest on a greater development of certain motor centers in one hemisphere of the brain and is apparently connected with the formation of

the language centers, which are usually in the left hemisphere. The left side of the brain controls the right side of the body, and vice versa.

The tendency to *communicate* is not peculiar to man; it is found in gregarious animals and others. But in man it is unusually strong. It manifests itself in many ways, such as gesture and speech, which are developed into systematic modes of expression by intelligence through the influence of the social environment (ch. xiii). Communicative behavior is greatly assisted by the development of the language centers in the brain, and by man's upright posture, which leaves his hands free to practice gesturing and writing.

Esthetic expression, the artistic touch which many human actions exhibit, has not as yet received a satisfactory explanation. Its early manifestation in childhood and among primitive races seems to indicate that it is a real inherited tendency.

Besides these special instinctive tendencies, there seems to be a general innate tendency underlying each *class* of instincts. We may regard walking, feeding, and the like, as indicating a fundamental *nutritive tendency.* In the same way we note a *reproductive,* a *defensive,* an *aggressive,* and a *social* tendency in human behavior. These are not acquired. They belong to human nature; they are based on something in our inherited nervous constitution.

Popular writers speak of an 'instinct of self-preservation.' Strictly speaking there is no such instinct. But we have inborn tendencies to nourish ourselves, to defend ourselves, and to perpetuate the species. Taking all these as a part of our general inherited bodily organization, it is correct to say that man has a very fundamental instinctive tendency to keep himself alive and to preserve his species.

Development of Instincts in the Individual. — Instincts and instinctive tendencies, like reflexes, belong to the inborn constitution of each individual. The nerve structure through

which they operate is provided for in the original germ cell from which the individual grows, and is derived directly from one parent or both. This does not mean that a given instinct is present at birth, nor that the appropriate nerve connections are already formed at birth. The nervous structure needed for many of the instincts is practically ready at birth, *and in some cases it develops long before: but no instinctive* action can take place till there is some actual stimulation and until the several reflexes which compose it are linked into a series. The welding of separate reflexes into an instinct is often not completed till a considerable time after birth. Human walking, for example, is usually not completely adjusted till some time in the second year of life. This is because the muscles of the legs are not sufficiently developed till then. The reproductive instincts are not fully developed till somewhere between the tenth and fifteenth years.

In short, any given instinct begins to manifest itself at a certain period of life, and the period at which it appears depends not so much upon the chance occurrence of appropriate stimuli as upon the *perfection of the nerve connections and effector organs.* If the proper stimuli do not occur at the right season, the appearance of the instinct is delayed, and in some cases it may never be perfected. But since we all live in the same general environment the appropriate stimuli usually do occur, so that the instinct appears sooner or later.

It is sometimes stated that instincts are invariable. This is not absolutely true. Instinctive movements are greatly influenced by various stimuli that occur while the act is being performed. In the act of walking we adjust our movements in different ways when we step up or down or walk on a slope, or if we encounter a stone in the path. Some of these variations are due to differences of pressure on the sole of the foot, others are due to visual stimuli from the objects we see ahead. Nor is this altogether a matter of consciousness. We adjust our walking movements to slopes and obstacles

quite as well when we are absorbed in conversation as when we are paying strict attention to the path in front. We step down from the curb or walk around a tree, often without being aware that we are doing so. There are similar variations in the instinctive actions of animals where there is no question of intelligence. They are due to variations in the stimuli.

The chief difference between the variations which occur in instinctive and intelligent behavior is that instinctive modes of expression *are not altered by past experience*, while intelligent expression depends essentially upon the effects of *retention*.

If instinctive expression is not modified by experience, how is it that walking and feeding and other instincts show the effect of learning? The explanation is that in such cases some of the inherited paths or lines of conduction in the nervous system are broken up and other pathways are substituted. To the extent that this occurs the behavior loses its instinctive character. In the complex cortex of the human brain the higher centers gather in and send out impulses which inhibit certain reflexes and reinforce others. The effect of this, as time goes on, is to transform our actions little by little from the instinctive to the intelligent type. In the human adult there are no pure instincts. Our behavior consists largely of intelligent actions which rest on an instinctive basis. The instinctive tendencies persist and develop along intelligent lines. The nearest we come to purely instinctive behavior is in walking, feeding, fighting, and other modified instincts.

Summary. — Before examining motor experiences (ch. xii), we must study the relation of responses to stimulation. Some responses are inherited, others are acquired by each individual. By *inherited* is meant that certain definite arrangements of nerves in the body are determined from the start; their natural connections are such that if a cer-

tain stimulus is given a certain definite response always follows.

The simplest inherited response is the *reflex*. A reflex is not learned — it is innate. Coughing, winking, etc., are reflex responses; they are the automatic outcome of certain stimuli; their nervous paths are inherited.

An *instinct* is a complicated form of response made up of a succession of reflexes. It is also innate. Instincts do not necessarily appear at birth. Any given instinct appears when the bodily conditions for it are ripe. Besides instinctive responses or movements we have certain *instinctive tendencies*. Imitation and other inherited tendencies express themselves in actions that are not inherited; but the tendency itself is innate.

Man has few pure instincts. Most of his inherited behavior is modified by learning. Nearly all our activities are partly instinctive and partly intelligent.

PRACTICAL EXERCISES:

49. Describe (or name) all the different sorts of muscular movements which you can observe in your face and head.
50. Examine a number of the most familiar reflexes given in Table X. Test in your case and report how far each is under voluntary control.
51. Analyze the motor processes included in three different human instincts, e.g., eating, walking, fighting.
52. Examine why you have the following tendencies: (*a*) to sympathize with your friends; (*b*) to collect objects of some kind; (*c*) to find out things you do not know.
53. Report all noticeable right and left preferences in your actions; e.g., which arm or leg acts first in putting on or removing your various garments.

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CHAPTER XI

INTELLIGENCE

Individual Adaptation. — If the same stimulus be applied to the same individual time after time, his responses may change. These differences in the effect when the external causes are the same do not throw doubt upon the uniformity of nature; they mean simply that *conditions within the organism* have changed. There are two distinct kinds of individual modifications in responses: *fatigue* and *adaptation.*

(*a*) The *fatigue* change occurs in instinctive actions and reflexes as well as in intelligent actions. Constant repetition of the same stimulus causes wear and tear in the receptors, *synapses, and muscles. There are destructive chemical* changes in the tissues which tend to weaken or inhibit the usual response, so that the outcome is different. If the knee be tapped repeatedly, the knee-jerk gradually becomes weaker. Fatigue is a condition of *diminished efficiency.* In ordinary cases fatigue disappears after a period of rest, when the exhausted tissue is restored by the building up of new chemical compounds.

(*b*) *Adaptation* acts in the opposite way. It is not an impairment of the response, but a distinct *improvement* due to more perfect adjustment. It is due not to destruction of tissue, but to the formation of new paths in the nervous system, or to gradual improvement of the old paths by cutting out useless movements. If you are unfamiliar with shooting, and practice firing at a target, you find after awhile that you begin to get better results. Your responses become better adapted to the situation; you make more hits.

The adaptation effect does not wear away when we rest;

it tends to persist. Increased adaptation of response is the most notable characteristic of intelligent behavior, and distinguishes it from instinct.

Conditioned Reflexes

Nature of Conditioned Reflexes. — The simplest form of acquired adaptation occurs in reflex actions. Under certain conditions a response which in the beginning was called forth by a certain stimulus, may become the response to a totally different stimulus. The new reflex acquired in this way is called a *conditioned reflex.*

Conditioned reflexes are built up when two stimuli occur repeatedly at the same time, one of which (A) leads to a definite and characteristic response, while the second (B) does not. After a number of repetitions of the two stimuli together, if B occur alone, it may bring about the response which originally belonged to A.

An example of this is the conditioned knee-jerk. If you tap a certain spot just below the knee-cap, the leg flies up. This is the natural knee-jerk reflex. In certain experiments it was arranged to strike the knee with a hammer held and operated by mechanical devices so as to insure uniform force and location of the blow. A bell was sounded each time before the hammer fell. During the experiment something went wrong with the apparatus. The hammer fell part way but did not strike. Yet the leg flew up, just as it was accustomed to respond to the blow. The *auditory* stimulus (B) brought about the response which belonged originally to the *contact* stimulus (A). The subject had formed a conditioned reflex.

This is a specially good example because there is no question of association of ideas. The knee-jerk is not under voluntary control; you cannot produce it by suggestion. In other cases there might be some doubt whether the new connection was automatically acquired; here there is not, and

we may assume that other simple conditioned reflexes are established in the same automatic way.

A dog sees a box containing food and smells the food; the smell stimulus causes a response in his salivary gland — saliva accumulates in his mouth. If the same box be brought in daily, a conditioned salivary reflex will after awhile be aroused by the mere sight of the box. If a bell be struck every time the box is brought in, after awhile a conditioned salivary reflex will be brought about by the mere sound of the bell, before the box is seen.

This has been definitely proved by Pawlow's experiment. Pawlow made an incision in the dog's salivary gland and inserted a glass tube which passed through the corner of his mouth and hung down. The saliva passed out through the tube and could be observed by the experimenter as it dropped. The strength of the conditioned reflex was measured by the number of drops per second.

Conditioned reflexes are found in man just as in lower animals. It is probable that the 'watering of the mouth' at the sight of a juicy peach is a conditioned reflex and is not due to an association of ideas. Our response to the dinner bell involves a more complex mental process and is not quite analogous to the dog's conditioned response.

The formation of conditioned reflexes depends upon the existence of branching connections in the nervous system. When two stimuli occur simultaneously their nerve impulses may come together in one of the centers. If the sensory nerve bearing one of these impulses has a definite motor path, the combined impulses will tend to follow that path. Suppose that at the outset the sensory nerve bearing the other impulse has no definite motor connections but its stimuli produce diffuse movements through one motor path or another according to the condition of its various synapses. Then, by repetition the synapses connecting this sensory nerve with the definite motor path of the other will be

strengthened. Eventually the connection becomes so firmly established that when the 'diffuse' stimulus occurs alone, its nerve impulse will follow the motor path of the 'reflex' stimulus and will bring about the response originally belonging to the latter.

The conditioned reflex is the simplest type of individual modification of behavior. It will readily be seen that the changes which it brings about in the animal's (or the man's) actions tend to be adaptive — that is, to be suitable or fitted to the general situation. For, if two stimuli occur together, a response suitable to both is likely to be suitable to either.

Intelligent Behavior

Intelligence. — When reflexes are altered, there are changes in the complex actions of which they form part. Instinctive behavior is modified by the acquisition of conditioned reflexes, and by other changes to be described later. In so far as our behavior is not fully determined by inherited paths in the nervous system it ceases to be instinctive.[1] Complex actions which are due to *individually acquired* connections of nerve paths are termed *intelligent actions.*

The words *intelligence* and *intelligent* are used in psychology in nearly (but not quite) the same sense as in popular language. Popularly the expressions *intelligent actions* and *intelligent behavior* imply that we realize that the actions in question are the proper thing to do. Psychology shows that individually acquired behavior *tends* to be suitable — though it is not always so. It also finds that we are usually aware to some extent of the fitness, but not always: when we have once learned to perform a suitable act it may be carried out just as automatically and unthinkingly as an instinct. It is best, then, not to lay stress on the 'awareness.' In psychology, *intelligent behavior* is defined as any complex action which is not inherited, but is acquired by the individual, provided the

[1] Instinctive means inherited, innate, inborn.

response be in any way suitable to the situation.[1] Intelligence means the *capacity* of an individual to break away from instinctive behavior and acquire new modes of action. Intelligence is often used as a shorthand term for intelligent behavior, just as instinct is used for instinctive behavior.

Although instinct is the usual form of behavior in sub-human species, there is a certain amount of intelligent adaptation in all animals except those low down in the scale of life. This is shown by experiments with the maze. [Fig. 73.] An animal is released at the entrance (A) of a maze, food having been placed at the far end or center (B). The hunger stimulus, reinforced by the odor stimulus, arouses him to action. He starts off and after a certain number of hesitations, false moves, and retracings reaches the food and satisfies his hunger. The same program is repeated on the same or successive days. It is found that after a number of trials the animal succeeds in reaching the food-box in a *shorter time*, and with *fewer false moves* as indicated by the total distance traversed. In an experiment with 27 white rats the average time was reduced from 467 seconds in the first trial to 40.3 in the eleventh, and the average distance from 4216.1 to 1029.8 centimeters. Even in species as low as the crayfish and other crustacea there is a slight reduction in time and distance after many trials in a simple maze.

The animal's behavior in the maze experiments consists of a long series of reflexes which, taken together, form a complex action. The action at first is instinctive, but it becomes modified in the course of time. The rate of improvement serves as a measure of the animal's intelligence.[2]

Adaptive changes in behavior are not limited to improving the *efficiency* of responses. The most important changes are those that bring about *new kinds* of response. Human be-

[1] This excludes movements that are entirely irrelevant, but includes errors, large and small, that occur during the process of learning.

[2] Compare Table XII, p. 260.

havior is far more subject to this kind of modification than the behavior of any subhuman species. In the human child

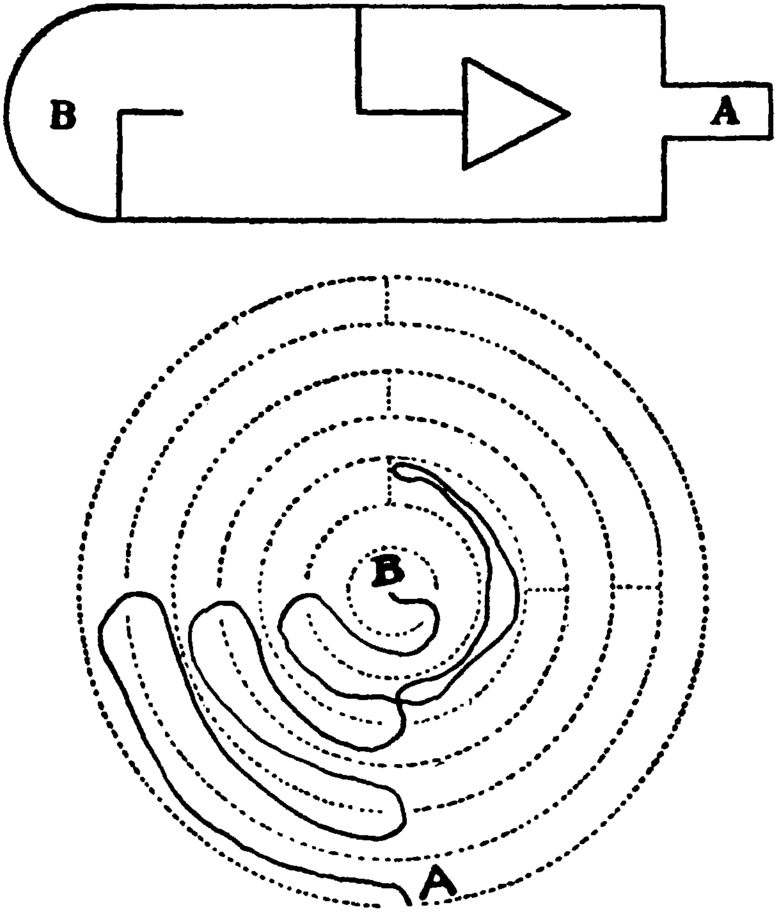

FIG. 73. — MAZES FOR INVESTIGATING HABIT FORMATION

Two mazes used to determine the rate at which an animal learns the right path from A to B. Upper figure is a simple maze used by Yerkes with frogs. One choice of paths at start, one choice near end. [From *Harvard Psychological Studies*.]

Lower figure is a maze used by Hubbert with rats. Heavy line shows actual path of one rat on 62d trial. See Table XII for results of this experiment. [From *Jour. of Animal Behavior*.]

we observe any number of instances in which new forms of response are developed through individual experience: talk-

ing, manipulating knife, fork, and spoon, buttoning the clothes, opening the door, climbing stairs, folding the napkin, writing, swimming, riding a bicycle, and many others. Adult acquisitions are generally concerned with more complex processes, such as steering a sail-boat or motor-car, typewriting, telegraphing, and shooting.

Habit Formation. — Learning, or habit formation, is the process of forming new connections in the nervous arc and perfecting these connections through repetition. There are two rather different sorts of learning: (1) The formation of *motor* habits, through coördination of muscular movements — as, for example, learning to typewrite. (2) The formation of *mental* habits; this means establishing new connections in the brain, — connections which have no immediate motor expression. When we learn to notice weather signs or to observe things 'out of the corner of the eye' or to think logically, or when we memorize a poem or the multiplication table, the acquisition is chiefly the forming of new paths in the brain centers; — there is eventually some motor result, but this is incidental.

The learning process is substantially the same in motor and mental habits, though the results differ. Both kinds of habit-formation involve two steps or stages of progress: (*a*) *Acquisition*, — making new connections in the nervous system; and (*b*) *Fixation*, — strengthening these newly acquired connections. These two processes supplement each other.

a. Acquisition. — A baseball pitcher finds a way to deliver a new curve — one that he has never pitched before. A billiard player makes a new kind of shot. A recruit in the training camp gains the ability to respond by the proper movements to each command in the drill manual. In every case the first time the new movement is made, or whenever it is altered, the man has *acquired* something. The acquisition is not a change in the muscles but a change in the nervous paths that operate the muscles. Intelligent acquisi-

tion[1] of new movements is the process of forming new paths of conduction in the *central part of the nervous arc.*

Acquisition does not involve the growth of new neurons nor the projection of new collaterals. The neurons and their branches have already been formed in pre-natal life. It is only the course of the impulse that is changed. The acquisition of new responses means that the nerve impulse is shunted from the usual path to some new path. This means that the impulse in some part of its course passes through a synapse which has not hitherto been used, instead of through the commonly used synapse. In Fig. 74, suppose the usual path of the impulse be along the neuron A and out into the neuron B1; then if on some occasion for any reason the impulse passes over into B2, a new path of discharge is opened and a new response is acquired.

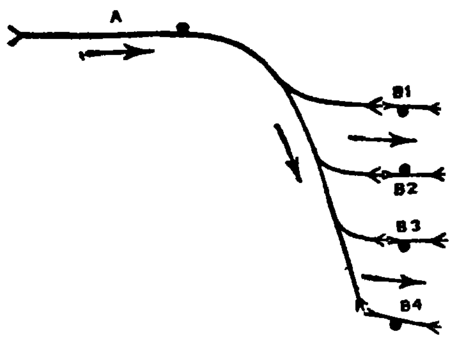

FIG. 74. — CHANGES OF PATH IN HABIT FORMATION

Diagram to illustrate the acquisition of new nerve paths. Nerve impulses travel along A in direction of arrows to synapses connecting with B1, B2, B3, B4, which are alternative pathways. (See text.)

How do these changes of path come about? They are made possible in the first place by the existence of manifold connections in the nervous system. There can be no acquisition unless the central neurons are provided with a number of collaterals or branches, each connecting with a different lower or higher neuron. The several synapses leading out from a given neuron must vary in their degree of resistance, and they must be capable of varying independently, so that at one time a certain synapse (connecting with B1) will be less

[1] Instinctive acquisition is a racial product and depends upon the evolution of the nervous system from generation to generation.

resistant than any of the others, at other times another synapse (connecting with B2 or B3). If there are no branches the nerve impulse will always follow the same path; and if there are several branches but a certain one of the synapses is always the path of least resistance, then the impulse will always follow that path.

Man has inherited an intricate system of multiple connections in the brain centers and particularly in the cortex. His central nervous system includes a vast number of alternative paths capable of being brought into connection. This is the real cause of man's superior intelligence as compared with other species.

But this only means that acquisition is possible. The question still remains, How is it actually brought about? The actual change of path in every case depends upon changes in the conditions of the synapses. There are at least three ways in which we form new paths: (1) One synapse may become *less resistant* to the passage of impulse than it was before; or (2) the synapse that usually carries the impulse may become *very resistant*, so that this pathway is blocked and the impulse passes over into the next best path; or (3) a very intense impulse may succeed in breaking through *several synapses at once*, just as a powerful stream of water not only fills the usual channel but trickles over into other channels as well. It is likely that the degree of resistance at synapses is determined by the quality as well as the intensity of the impulse, and that it depends also on conditions in the next higher neuron — the neuron into which the impulse seeks to pass.

These three ways of altering the nerve paths give three kinds of acquisition: (1) *Accommodation* occurs when a new path is opened. In reading aloud, when we see a new word the nerve impulses are shunted into new paths according to our retention and memory of the several letters or syllables composing the word; — there is an accommodation of response. (2) *Inhibition* occurs when the old pathway is

blocked. When we see some one coming who looks like a friend we prepare to greet him in one of the usual ways; if when he comes closer he proves to be a stranger, the path of response is closed and the bow or greeting is inhibited. (3) *Diffusion;* the impulse may spread into several paths simultaneously — into new paths as well as old. When we are walking to the station to catch a train, if we hear the locomotive whistle, there arises a very powerful nerve current, due to a combination of the sound sensation and the muscle sensations concerned in walking; this causes the motor impulse to spread into several paths; the result is a much livelier response.

Sometimes these forms occur together. Inhibition is combined with accommodation when we start to wind a clock the wrong way. If the key does not turn (inhibition), we thereupon alter the course of the motor impulse and twist it in the opposite direction (accommodation).

Most examples of acquisition drawn from every-day life involve complicated actions. To study the process systematically we must start with the simple reflexes which compose our actions and observe how these are modified. The conditioned reflex is a typical case of accommodation. When you learn to check the eye-wink, or the cough, you are inhibiting these reflexes. Diffusion may be studied by attempting to twitch the ear voluntarily if you have never done so before. The effort to raise the ear causes the motor impulse to spread to various regions near by. You raise your eyebrows, move your scalp, etc. If the effort is finally successful, it means that the impulse, in spreading, has forced its way into the hitherto unused pathway leading to the levator muscle of your ear.

b. Fixation. — Fixation is the process of strengthening the connection in the newly acquired path. The passage of the nerve impulse through a new synapse tends to 'set' the structure of that synapse so that it offers less resistance in

future. If only one impulse of the sort occurs the effect tends to wear away; the acquisition is lost and the old response returns. But if another impulse of a similar sort occurs soon after, it is more likely to pass through the new than through the old channel. An acquisition becomes permanently *fixed* when the new pathway is finally established.

The rate of progress in fixing a new path depends upon four factors: *repetition*, *intensity*, *recency*, and *conflict*. The new path is more firmly established in proportion to the number of times the given stimulus is *repeated*. Fewer repetitions are needed when the nerve impulses are very *intense*. The repetition is more effective if the original acquisition occurred *recently*. These conditions of habit-fixation correspond to the three laws of recollection.[1] Recollection, in fact, is just a special case of fixation. The connection between visual impressions and verbal memories becomes fixed in the same way as motor habits, so that the sight of a certain face leads to the recollection of the man's name.

The remaining condition of fixation, the principle of *conflict*, corresponds to the first law of forgetting.[2] The progress of fixation is hindered if, meanwhile, impulses of a different sort occur, which use the old pathways. In such cases the old connection is maintained along with the new, and fixation takes longer. Suppose when we start to learn typewriting we use two machines with slightly different key-boards or with the shift-key in different places. Here we have to learn two different responses to similar stimuli. The two responses conflict, and this retards the progress of fixation. If we attempt to memorize a poem in which each stanza begins with the same line and then runs on differently, there is the same sort of conflict.

As the process of fixing a habit goes on, two different changes in the behavior take place — our actions are improved in two different ways:

[1] See ch. viii, pp. 186–187. [2] P. 188.

(1) As the new connections grow stronger there is less hesitation, so that less time is needed for performing the action. This effect is called *facilitation* of the act.

(2) As the new connections become stronger there are fewer diffused impulses along alternative paths, so that various useless and erroneous movements gradually drop out. This is called *elimination.*

LAW OF FACILITATION OR SPEED: As the newly acquired path is strengthened, the new response tends to proceed more rapidly.

LAW OF ELIMINATION OR ACCURACY: As the new connections improve, there are fewer useless and erroneous movements; the response becomes more precise and more accurate.

These two types of improvement may readily be observed in the progress of any complicated habit, such as typewriting. After you have used the machine some time you find that the movements follow more rapidly. At the same time you will find that you strike fewer wrong keys, and make fewer useless movements, such as wrinkling the brows, puckering the lips, exploring the keyboard with the eyes to find a letter.

If you work methodically at learning a new habit your progress may be measured quite exactly in terms of speed and precision. The *speed* of performance is reckoned either by the amount accomplished in a given time or by the time required to perform a stated task. In learning to typewrite, if you practice an hour a day, your improvement in speed may be measured either by the number of words typed in five minutes, or by the time required for typing a single page day after day. *Accuracy* is measured by the number (or percentage) of errors; in learning to typewrite you compare the number of mistakes made from day to day in typing one page.

Experiments on the rate of learning have been made in many common habits, such as telegraphing, juggling three balls, shorthand, and mirror-writing. Fig. 75 shows the progress of a novice in learning to telegraph. The 'curve'

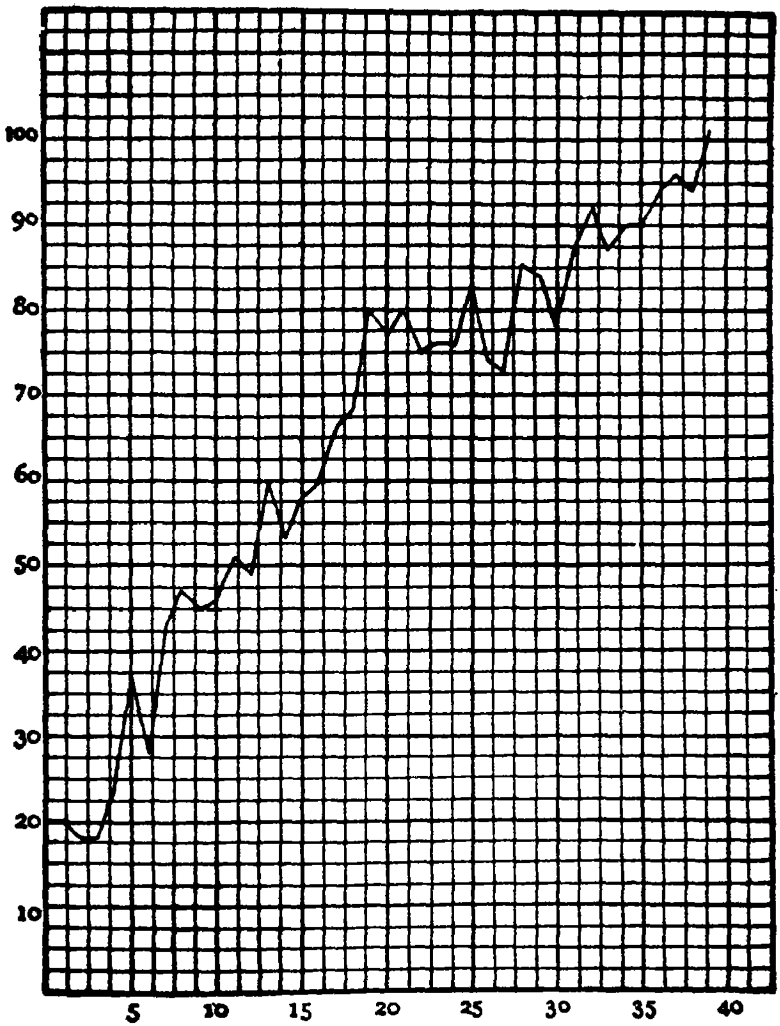

FIG. 75. — CURVE OF LEARNING

Shows the progress of facilitation (speed) during the fixing of a habit: learning to telegraph. Vertical numbers denote the number of words which the learner was able to telegraph in 5 minutes after 30 minutes of practice. Horizontal numbers denote successive days. The experimenter was entirely unfamiliar with the habit at the start. [From Swift, in *Psychological Bulletin.*]

(which is really a jagged line) represents the number of words tapped off in 5 minutes on successive days with the same amount of daily practice. It shows the gain in speed, not in accuracy.

TABLE XII.— PROGRESS OF LEARNING

A. Habit Formation in Man:

Day	*Av. Time (sec.)*	*Av. No. of Errors*
1	79	29
2	72	27
3	63	14
4	60	10
5	56	7
6	54	4
7	53	2.5
8	49	2
9	47	0.25

Average attainment of 4 human subjects learning to typewrite nonsense groupings of 7 different letters, arranged in a series of 55 letters. The series was performed 3 times daily. Table shows average time and average number of errors per series. (J. H. Bair, *Psychol. Monographs*, No. 19, p. 17.)

B. Habit Formation in the Rat:

Trial	*Av. Time (sec.)*	*Av. Dist. (cm.)*
1	467.0	4216.1
6	186.6	1719.2
11	40.3	1029.8
16	25.5	868.4
21	24.2	739.9
26	26.1	756.5
31	31.8	593.2

Average attainment of 27 white rats in maze experiment. Two trials each day; animal allowed to feed after second trial. (H. B. Hubbert, *J. of Animal Behavior*, 1914, 4, p. 63.)

Progress in both speed and accuracy are shown in Table XII. The upper table (A) shows the average progress of four men in typewriting nonsense groups of letters. Their speed is measured by the time required to typewrite fifty-five letters and their accuracy by the number of errors. The same sort of measurements may be applied to animal learning, though the habits involved are much simpler. Table XII B shows the

average progress of twenty-seven white rats in learning to thread a maze. The speed is measured by the time required; in this experiment the accuracy is measured, not by the number of errors, but by the distance covered by the rat in his wanderings, which indicates the *amount of unnecessary movement.*

In some experiments on human learning an interesting fact is brought out. After a certain amount of practice the progress appears to cease; there is virtually no improvement. Then if practice is continued, after a time the man takes a new spurt. If the progress is represented by a curve, the period of no-progress is a flat stretch between two slopes. This flat part is called a *plateau.* In Fig. 75 there is a plateau between the 19th and 30th days. Plateaus are probably due to our having about reached the limit of improvement through facilitation and elimination. The new rise in the curve indicates that another *acquisition* has taken place, which in turn becomes gradually fixed.

An interesting practical problem in learning is whether progress in fixation is more rapid when the repetitions are crowded into a short period of time or when they are spread over a longer period interspersed with intervals of rest. Contrary to the general impression, it has been found that progress in memorizing is faster (in the long run) with *shorter practice periods*, interrupted by rather long rest intervals. But the progress in memorizing a speech is more rapid if we learn it *as a whole* than if we split it up into parts and learn each part separately.

Relation between Acquisition and Fixation. — Our world presents many constant and many variable features. Certain situations occur over and over again with no significant changes. Each morning we have to dress, we breakfast under much the same conditions, we pursue our regular occupations in much the same way, we are constantly meeting the same people, we walk the same streets. On the other hand

we vary our dress according to the weather or the occasion, we travel, we indulge in a variety of recreations, we meet new people, we find new tasks to perform. Most of the situations in human life are too complex and varied to be solved by instinctive behavior. Our *inherited* nervous connections are not sufficiently elaborate to enable us to perform the duties of civilized human beings.[1] Even the simple act of putting on our clothes and buttoning them must be learned.

The variable situations in life require acquisition of new modes of behavior, and the constant situations need fixation of responses. We must (1) adapt ourselves continually to new situations by new acquisitions, and we must (2) automatize many acts by fixation, in order not to waste time over details that are always the same. One process is just as important as the other; and both are phases of intelligence.

Most situations in life contain both old and new elements. When we write a letter, we hold the pen and manipulate it in a stereotyped way, but we write different words and sentences. We learn in childhood how to write — that is, how to wield the pen. This becomes a fixed habit, so that finally the act of writing becomes as automatic as any instinctive act.

Because fixed habits proceed automatically, some writers regard them as cases of *lapsed* intelligence. This is a wrong notion. Intelligence means *capacity for adaptation*. Habits are individually acquired modes of behavior, and are just as suitable to the permanent factors in the environment as new reactions are suitable to new conditions. A habit is as much a display of intelligence as a new response. There is no lapse of intelligence in fixed habits — only a decrease in the vividness of the impressions. New responses (acquisitions) are accompanied by vivid consciousness, while habits (fixations) are not. A deeply rooted habit, such as operating a pen in writing, is a case of lapsed *consciousness* but not of lapsed *intelligence*.

[1] Ants have an elaborate inherited nervous equipment, and can meet some very intricate situations instinctively.

It cannot be emphasized too strongly that the all-important fact in psychology is the creature's *response to the situation which confronts him.* Consciousness, awareness of the situation, is only one factor in the process. If the best results are reached by making the brain connections more automatic and reducing the vividness of consciousness to a minimum, such a condition marks a *higher* degree of intelligence than the conscious planning of every detail. The dressing habits formed in childhood enable us to prepare for the day's work more rapidly. We are able to think out some other problem at the same time. Notice how much time and effort is spent by a child who is just learning to dress. Notice that in your own case the performance of these stereotyped actions may be actually *impeded* if you attend to each movement. In all fixed habits subconscious behavior is more effective, more adaptive, more intelligent, than conscious behavior.

Fixed habits always tend to be adaptive (or suitable), because none but suitable actions are likely to be repeated constantly and become fixed. But does a new acquisition tend to be adaptive? Yes and no. If by an acquisition we mean *every* new variation that occurs in our movements and expression, then a large part of our acquisitions are by no means an improvement. We may try a dozen times before we hit on the right movement to accomplish what we are after. But most of these failures drop out at once; they do not count as acquisitions. The real acquisitions are those that get us somewhere. These suitable acquisitions are selected, and tend to persist. The selection of suitable new responses comes about in two different ways: (1) through *trial and error* and (2) through *associative memory.*

1. **Trial and Error Learning.** — *Trial and error* is a process which includes (*a*) persistent trials with wrong responses, and in the end (*b*) accidental success. This type of adaptation is found in subhuman species as well as in man. Suppose a dog is confined in a yard with a latched gate. He sees a cat out-

side and jumps at the gate time after time, pawing it and barking vigorously. The gate holds despite his pawing and barking. By chance his paw touches the latch-bar and releases the latch; the gate flies open, and the dog gets out. The jumping and pawing are persistent trials with misfit responses; they do not bring him to the cat. Pressing the latch-bar is an *accidental variation* of response which brings success. For the very reason that it solves the difficulty it is the last to be tried; and because it was the most *recent* of the series, it is more likely to recur than any of the other responses the next time the same situation is presented.

Many human habits are the result of trial and error learning. In first learning to ride a bicycle we make a lot of useless movements, which wabble us zigzag along the road and bring about numerous falls. These are all responses to our visual and static sensations. They are not successful at first; but we persist and try all sorts of variations. Certain twists and body movements keep us upright and steer the wheel in a straight course; these responses are successful and gradually supplant the rest. In a word, persistent trial is likely to meet final success by sheer chance, and the successful response, being the last in the series, is more likely than any other to recur in future. Acquisition by trial and error, then, does tend to be adaptive.

What goes on in the nervous system during the trial and error process? The key to the explanation is the *persistence of the stimulus*. In the case of the dog at the gate, the dog sees and smells the cat all the time. The cat-stimuli keep sending nerve impulses to the dog's brain and lead to a continuous series of movements. The gate prevents the completion of his usual response — to pounce on the cat; the motor response is inhibited and finds some other channel. The jumping and pawing movements are accommodations of response due to the increased resistance of certain synapses and the lowered resistance of others. When the new response

succeeds, the synapse through which the impulse passes remains a path of lesser resistance *because* the situation is solved and the bothersome stimulus is removed; therefore, the next time a similar situation occurs this channel is more likely to prove the path of least resistance than the pathway through other synapses.

2. **Associative Memory.** — Learning by means of *associative memory* is a higher type of acquisition. The stimuli do not result in trial responses. Instead, the nerve impulses pass from center to center *in the brain*, arousing a succession of images and thoughts. We picture to ourselves various ways of acting; if one course of action does not solve the difficulty, we picture another, and so on till we picture some action which brings about the suitable result. Then at last the nerve impulse passes out into the appropriate motor channel and we act.

An example of learning through associative memory is the attempt to solve a chess problem or a mathematical puzzle. We think over the various ways of proceeding, one after the other. As long as our thoughts fail to present a satisfactory solution, the nerve impulses continue their course in the brain, arousing one thought after another. When the thought of the correct solution arises, a motor impulse is started and results in action; the bothersome situation is gone and ceases to stimulate our thinking.

This method of learning is called associative memory because our thoughts depend altogether on the revival of retention traces in the brain, which arouses memory and mental pictures. Instead of actually making the chess moves we picture them mentally, and these pictures form trains of association (ch. xiv). The thought of the *problem* keeps the impulse going rather than the sight of the chess-board. Associative memory involves higher centers in the brain and better connections of the neurons than trial and error acquisition. It resembles trial and error in one respect:

the last thought, which is the successful one, is most likely to recur the next time a similar situation is presented. So that acquisition by the associative memory method tends to be adaptive also.

Growth of Intelligence. — Intelligence, like instinct, is a racial growth. The *capacity* to acquire new responses evolves gradually from lower to higher species of animals as the nervous system becomes more complex. But unlike instinct it is also an individual growth. In the human species intelligent behavior develops gradually in each individual and may continue to progress until far beyond middle life.

Every intelligent act depends upon the perfection of certain simpler acts which compose it. The act of writing depends upon our ability to move the fingers and wrist so as to trace each letter properly. This in turn depends upon our ability to hold a pen or pencil. After we have learned to form the letters by means of certain wrist and finger movements we extend the same act to other muscles, when we write large upon the blackboard.[1] Certain elements in the act of writing are utilized in typewriting and typesetting, while other elements in handwriting are lacking in both of these acts. Owing to the intricate interconnection of the various brain centers in man an almost infinite number of new motor combinations are possible. These new actions are due not merely to differences in the stimuli, as in the case of instinct, but to the manifold connections in the brain.

Human habits are so complex that it is difficult to classify them satisfactorily. Some of them fit into the same general types as the emotions and instincts. Our table habits are obviously *nutritive;* dressing and house-building are *defensive;* warfare is *aggressive* behavior; educational acquisitions are habits of *individual development.* But most habits belong to several different classes. Games are social; they are also nutritive if they give us bodily exercise; or developmental if

[1] See Fig. 80, p. 368.

they exercise our thought processes. Boxing is both aggressive and defensive; and it is nutritive when used as a mode of exercise — or if we adopt boxing as a profession to gain our livelihood; a friendly bout is social behavior.

The difficulty of classification is due to the fact that intelligent behavior represents a response to the *entire* situation which confronts the creature, rather than a reaction to this or that particular stimulus. Intelligence tends to express the *organism as a whole*, not merely some special phase of organization. There seems to be no natural scheme of classification, except the very practical division into *useful* and *detrimental* habits.

Training of Habits. — Given a sudden emergency, some men generally do the right thing, while others always seem to fall down. The latter individuals need special training. Readiness to meet unforeseen situations depends upon training in several phases of mental life. In the first place, we must train our *perceptions* — we must learn to observe quickly and exactly. If we perceive instantly the real meaning of the situation, we are in a better position to act properly. If we can pick out the significant details, we are more likely to see where to direct our efforts. *Memory* training is also important in meeting new situations. Few situations are wholly new; the organization of our memories will assist us in coping with situations that are partly familiar. The training of our *thought processes* (ch. xiii) is one of the most important factors in adaptation. And finally, training in the *fixation of habits* is essential even in connection with new situations.

From the very nature of the case there can be no special training in the 'acquiring process' itself. The unexpected is unexpected. We can only train the underlying processes of observation, memory, and thought, which will render any new situation less strange. When we are not confronted with an emergency but with a general problem of action, the nature of the acquisition process itself offers a helpful sugges-

tion. The trial and error method is fundamental, and the only way to insure success is to stick to the task — to persevere. The copy-book motto, "Try, try again," represents a real principle of mental activity.

The other side of intelligence, the fixation process, admits of much more systematic training. The process of strengthening habits has been investigated in the laboratory and some definite quantitative results have been obtained which have a practical value. We have already noticed that, in certain kinds of learning, progress is quicker if the practice periods are comparatively short, with periods of rest in between. These results bear directly on the length of study periods in schools. How much time should be devoted to one subject at a stretch? How long should the recreation periods be, and how should they be distributed? In recent years, much has been *accomplished in the psychology of pedagogy,* which it would take too long to describe here.

The importance of cultivating useful habits can scarcely be overestimated. The habits involved in dressing, writing, table manners, and general social intercourse are essential to a well-ordered life. We cannot respond to *new* features in the environment unless we have developed habits which meet the *permanent* phases of life.

A habit tends to become detrimental to our welfare when it is too firmly fixed to admit of modification, or when it usurps the place of other, more useful responses. If we are so wedded to smoking that we must drop work for a cigarette at important junctures, or if we are so fond of telling anecdotes that we cannot readily listen to others, we are likely time and again to lose certain business or social advantages. There are also mannerisms and stereotyped actions which waste time and energy, or which are disturbing to others. Nervous movements, drumming with the fingers or tapping with the foot, hemming, coughing, and giggling are useless habits; a shrill tone of voice, uncouth table manners, whistling in public, and

the like are socially annoying. All these may be classed as 'bad habits' from the social standpoint. Biologically and psychologically bad are such habits as intoxication or the habitual use of drugs, which impair the vital processes and weaken our mental life.

The practical problem in such cases is how to break the habit — how to modify it into a useful form or suppress it entirely. This is one of the hardest problems of life. In extreme cases the individual seems powerless to break the habit by himself. Drug habits are especially masterful because they produce a physiological state which acts as a powerful stimulus to repeat the action; drastic measures *by others* seem necessary to check this class of habits.

Some habits can be checked by substitution. Nervous drumming with the fingers may be broken off if each time we catch ourselves at it we begin some other hand-and-finger movement; or if we turn to some useful occupation involving the use of the fingers. Day-dreaming may be repressed by reading or by trying to solve some useful problem. A man who smoked to excess broke the habit by taking a long trip where no tobacco was available.

Some habits can be broken by interposing an irrelevant stimulus. A sudden shock will sometimes shunt the motor impulse into other paths. This explains how a bad habit is often cured by punishment or through the shock of being caught in the act. Mutual assistance is extremely useful here. If friends agree to coöperate in the proper spirit progress is more rapid. Reprimanding and ridiculing are apt to produce bad effects even though they break up the habit. Habit-breaking is such a vital matter that a systematic study of its principles is well worth while. The schoolmaster should know how to unteach as well as to teach.

Summary. — Intelligence means the ability to acquire new and suitable forms of response by individual modification. It means changing our modes of behavior from the inherited

ways of acting to something new. The simplest type of modification occurs in the *conditioned reflex*. A higher type is the transformation of instinctive behavior into *intelligent behavior*. This requires a complex nervous system with manifold connections.

The learning process, or habit-formation, includes two steps: *acquisition* and *fixation*. Acquisition means the performance of some new response; in fixation we improve a new response by making it more exact and more rapid. These two processes go together.

There are two methods of learning: *trial and error*, and *associative memory*. In the former we persist in making various wrong responses till at last we happen upon the right one — which tends to supplant the rest. In associative-memory learning we think over various solutions till we happen to strike the right one; this supplants the other thoughts.

A fixed habit is just as intelligent as a new acquisition if it enables us to meet the situations in life. New acquisitions depend on our having certain fixed habits as their foundation. A habit is 'bad' only to the extent that it prevents new acquisitions or interferes with our individual or social welfare.

PRACTICAL EXERCISES:

54. Experiment with the formation of some new habit. Practice a certain amount daily and record your progress in speed and accuracy. [This should be started two weeks ahead.]
55. Make a list of 'useless' and 'annoying' habits observed in those around you, including some of your own.
56. Take some trivial useless habit and try to break it. Report the methods used and the degree of success.
57. Practice mirror-writing, looking in the mirror attentively, with your hand concealed from direct view. Report any notable feature of the experience.
58. Try to twitch your ears. Observe and report what movements you make in your efforts, and what success you attain.

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CHAPTER XII

VOLITION

Motor Experiences. — In chapters x and xi we have examined the different kinds of behavior. All behavior of whatever sort is response to some stimulus. In all complicated behavior there is a central process of adjustment between the stimulation and the man's response; and in connection with this central nerve activity there arise sensations, perceptions, and other experiences. When you see a ball coming swiftly toward you, and you step aside to avoid it, your perception of the ball is an experience which arises in connection with the adjustment process in your brain; the perception takes place *after* the stimulus (the light from the ball) strikes your eye and *before* you move. You perceive the ball, and then you side-step.

But this is not all. We know not only what stimuli are affecting us at a given moment, but how we are responding to them. You are aware that you are moving out of the path of the ball. You get this information through *muscle sensations* which arise after the response has begun. Your experience of making the movements is a very different sort of experience from your perception of the ball. Motor experiences are experiences of our own movements. They are stimulated by the contractions of our muscles when we are actually making the response; they inform us about our own responses and not about the stimulus which started the response. This information helps us to guide and control the progress of the movement.

Motor experiences are composed of kinesthetic or muscle sensations. Every movement, whether reflex, instinctive, or intelligent, which involves muscular contraction, gives

rise to muscle sensations.[1] In the case of reflexes these sensations are generally weak; they do not form independent experiences, but enter as marginal elements into some other experience that is present at the time. We know we are winking or coughing. But the chief experience when we wink is a darkening of the visual field; when we cough the experience is partly of hearing the sound of the cough.

In instinctive and intelligent acts the muscle sensations are more apt to combine into definite experiences; they form special sorts of experience, which are different from any of the kinds so far considered.

CONATION

Nature of Conation. — Our simple motor experiences are usually not vivid and have never received a popular name. Psychologists have adopted the term *conation* for this kind of experience. A conation is an experience made up largely of motor sensations. It gives us direct knowledge of our own bodily attitudes and movements.

There are frequently other elements in a conation besides muscle sensations. If the head or whole body is moved, we have static sensations from the semicircular canals. These are motor sensations, though they do not come from the muscles. The external senses also contribute to the experience. You see your arm moving; these visual sensations form part of your conation. In certain diseases where the muscle sense is destroyed, the patient is not aware of his movements unless he sees them; he can move his arms and legs if they are visible, but is unable to do so with his eyes shut. Touch also furnishes information of our movements, through the rubbing of our clothing on the skin.

The special qualities of conation are *effort*, *strain*, and *resistance;* where the static sensations enter in, there is also a nameless quality which may be called *whirl*. The external

[1] Glandular reflexes may produce systemic sensations.

senses add no special quality to the experience, but they tend to arouse slight muscle sensations or images. We notice this on a train when it starts smoothly, or if our own train is standing still and a train close by starts to move. The sight of the motion leads to an impression of motor effort on our part.

Conations occur in connection with reflex actions, instinctive movements, and habits. We have *reflex conations* occasionally, when a reflex action causes vivid muscle sensations. When we start at a sudden noise, the movement arouses a conative experience. Coughing and sneezing are accompanied by conation. Usually the sensations arising from simple reflexes do not give definite conations, but are incidental elements in our perceptions or feelings.

Instinctive conations most frequently accompany the so-called 'nutritive' instincts, such as wandering, acquiring, cleanliness. In other classes of instincts the systemic sensations are apt to be more vivid than the motor; in fighting, sympathizing, mating, and even in modesty reactions, the experience is an emotion and not a conation.

Habit conations are motor experiences which accompany the performance of well-established habits. We are vaguely aware of our activity when we are dressing; there is no vivid experience of the various movements unless we meet some difficulty, such as a misplaced shoe or the loss of a collar button. Then all at once the response ceases to be automatic and the motor experience is no longer a conation, but a volition.

Conations are neither so vivid nor so important in life as perceptions, memories, or feelings. The motor sensations of instinctive movements are usually overshadowed by other elements, so that the experience is not a true conation. If the systemic sensations are strong the experience becomes an emotion; if vivid images or thoughts are present it becomes a volition. Intelligent actions, except automatic hab-

its, usually require thought, and their experiences rise to a higher level than conation.

VOLITION

Will and Ideomotor Activity. — In man, responses to stimulation are frequently delayed. The intricate system of connections between our various centers permit the nerve impulse to travel from center to center before it discharges into a motor pathway. As the impulse passes through each center, ideas are aroused corresponding to the memory traces retained in that region. When at length the nerve impulse discharges, our action is as much an outcome of these ideas as a response to the original stimulus. Such responses are called *ideomotor* actions, in contrast to *sensorimotor* actions, which are responses to sensory stimuli. If you stop to think, even for an instant, before you act, your action is ideomotor. If you are lying in bed in the morning, vegetating comfortably, and you suddenly remember an engagement at 8:30, you jump up like a flash. The movement is started by the thought — not by a direct sensory stimulus; it is ideomotor. If the alarm-clock wakens you and you jump out of bed, the act is sensorimotor — the stimulus is a sensation, not a thought.

The distinction between sensorimotor and ideomotor action is not quite the same as between instinctive and intelligent action. All reflex and instinctive acts are sensorimotor, but not all intelligent acts are ideomotor. Many of our habitual acts are quite automatic; they are sensorimotor, though they have been acquired by a learning process and are therefore intelligent. Your response to the thought of lateness is ideomotor and intelligent. If some one douses you with water or pricks you with a pin and you jump out of bed, the act is sensorimotor and probably instinctive. The man who starts to change his collar for dinner and finds he has undressed completely and is turning down the bed, is acting in a

sensorimotor way, but the act is not instinctive; it is a series of actions which he has learned — acquired individually — and has reduced to a perfect habit; in fact, the habit is altogether too perfect.

The kind of experience which accompanies ideomotor actions is called *volition* or *will.*[1] A volition is a complex experience made up chiefly of two sorts of elements: motor sensations and ideas. When we *will* to do a certain thing, we have a thought of the action, together with certain muscle sensations of effort or memories of such sensations. Volitions are generally more vivid than conations.

Volition is especially important in life because the idea which starts the action is an anticipatory image or purpose; it represents *what we are going to do.* Suppose you plan a trip to the mountains and afterwards take the trip. When you make the journey you produce actual movements and receive sensations which correspond to the image experiences that you had in making your plans beforehand. Just so far as you accomplish what you planned to do you bring the events of the outer world under your own control. You think of a certain situation, and as a result of your actions this situation, which you previously thought of, is finally brought about. Your will has changed the course of events in the outer world.

The actual working of ideomotor activity is often misunderstood. It is commonly supposed that the idea of a movement tends to produce that very movement — that the idea directs the nerve impulse into the proper motor path.[2] This is not the case. There is no inherited or natural connection between the idea of a given movement and its execution. Every idea tends toward *some* expression; but the *exact sort* of expression is in the beginning a matter of chance. It may be *any* sort

1 Strictly speaking, 'will' is the *capacity* for ideomotor activity; 'volition' is the *experience* which accompanies the action; the act itself is 'voluntary.'

2 Even so acute an observer as James held this view.

of movement. There is no inherited adaptive connection in volition as there is in reflexes.

When you will to pick up a book, you grasp it at once. But this is the result of a habit; there is no *inherited* tendency to pick up a book when you will to do so. This is evident if you watch a very young child trying to pick something up. He fumbles about, and even if he finally succeeds, the act is performed awkwardly; he has not yet learned to connect up the idea with the proper motor impulse. Watch a child trying to copy the letters of the alphabet or trying to draw a picture. Or try yourself to perform some action which you have never learned to do, such as twitching your ears. The idea is vivid, and it results in various movements, but it does not issue in the movement which you willed.

All ideomotor responses must be learned; the proper connections between brain centers and motor paths are acquired by trial and error. In adult life all our ideas of action lead to the appropriate movements except in rare cases, such as ear-twitching. This is because the *right response has already been selected.* If the child thinks of picking up a book, and the right movement happens to follow, the muscle sensations reinforce the idea and make this particular nervous connection stronger than others, so that the next time the proper motor impulse is more likely to follow the idea. In this way our volitions come to be followed by just the movements we want to make. The ability is not inherited, but acquired.

Volition is a distinct advance over the kinds of experiences which we have so far examined. It *anticipates* what is going to happen. The will is not (like perception, memory, and emotion) concerned chiefly with the reception of information from the outer world or from our own bodies, but with *action by the individual upon the environment.* The volition experience leads to voluntary activity, which is a great step toward control of the physical world by living beings.[1]

[1] Instinctive behavior involves some control over nature. Volition increases this control tremendously.

Voluntary Activity. — Voluntary activity is distinguished from other activity by *deliberation* and *choice.* The latent period between the stimulus and response is longer. The delay is due to the fact that the motor expression is checked and a train of ideas take place before the action begins.

The *deliberation* which precedes voluntary acts is not always long. The length of the latent period depends on the nature of the situation. An intricate course of action, such as the choice of your career in life, generally requires a long time to think out. But such situations are comparatively rare. Most of our voluntary acts are decided quickly. The latent period is often very short. When you are reading a book and the dusk gathers, you suddenly notice that it is too dark to read without great effort. Immediately you get up and turn on the light. There is no apparent delay. Yet the act does take longer than a simple sensory response. The sensory response to this situation would be to drop the book and close the eyes; in voluntary action this immediate response is checked and the idea of lighting follows; there is a slight delay before you act.

The *choice* which takes place in voluntary actions is due to the complexity of the nerve impulses. When our motor expression is checked or inhibited, various ideas follow in succession, each representing some different course of action. When at length one of these becomes so strong that it leads to nervous discharge along some motor path, the result is a voluntary movement. On a holiday morning my first 'plan' is to spend the day reading in the library. The bright spring weather suggests a motor trip through the country. The motive of duty suggests finishing a half-written article. Finally, the thought of a long, brisk walk, combining pleasure with exercise, proves the most powerful impulse, and my voluntary activity proceeds along this line.

Volition is selective, not because it determines events which are otherwise indeterminate, but because it tends to bring

about the *fittest* actions, instead of the *most obvious*.[1] In any response the path of motor discharge is along the line of least resistance, but in voluntary action the nerve impulses in the brain pass from center to center before the motor impulse starts; and during this period of suspense we think of the various alternatives. As a result of the delay and of the changes in the central nerve impulses, the action when it does start tends to be more suitable than an immediate response would be.

Relation of Volition to Intelligence. — We have distinguished two sorts of motor experiences: (1) Simple motor experiences or *conations*, which are made up chiefly of muscle sensations; and (2) *Volitions*, composed of muscle sensations and ideas. These two are alike in that they give us information about our motor attitudes and the movements we are making, and so enable us to guide the course of our movements and control our actions. You *keep on* walking or steering your bicycle or tying your necktie because you are *kept informed every instant* as to how your movements are progressing. Motor experiences have a different meaning in our lives from perceptions and memories of external objects or from feelings of our own systemic conditions. These other experiences are chiefly receptive; motor experiences not only tell us what we *are* doing but suggest the way we *shall* act.

Leaving out of account simple reflexes and autonomic activities, human behavior is mainly of two sorts: instinctive acts and intelligent acts. Instinctive behavior is inherited; that is, we inherit nervous paths and connecting synapses which enable us to perform these actions without a course of learning. Intelligent behavior is not inherited; we do not inherit definite paths and connections for this type of action,

[1] The question whether the will is *free* has been debated for ages and has not yet been finally settled. It is not so important a problem if we emphasize the delay factor and the notion of fitness.

but merely the possibility of making these new connections (among others) by acquisition and fixation.

A distinction must be made between the *way we acquire the ability to perform* an act and the *way we perform* it. Instinct and intelligence are two different ways of acquiring motor ability. Instincts are racially acquired; habits are individually acquired — that is, they are *learned.* But once a habit is acquired, the way we actually perform the act may be just like an instinct. In other words, not all of our intelligent acts are performed voluntarily. Some highly intelligent, adaptive actions are sensorimotor; the motor experience which accompanies them is a *conation*, not a *volition.* This is the case when the action has been completely fixed or established.

Most of our actions in every-day life are a mixture of old and new movements. We rarely meet an entirely new situation, nor yet a situation without some new element. Most situations are partly a repetition of familiar circumstances, but with something in them which is quite different from anything we have experienced before in the same connection. So our responses are largely automatic. But if they are to suit the situation they must be partly voluntary also. Removing the collar is a fixed habit; but whether we shall put on a fresh collar or continue undressing depends on other factors in the situation. This requires thought and volition if our response is to be suitable.

Volition is useful only so far as the situation is new or ambiguous. It impedes the performance of a stereotyped habit to attend to each movement closely. Intelligence means attention to the branch-points and alternatives of behavior, with voluntary control of behavior at these points; intelligence also means inattention to stereotyped actions and letting them proceed automatically, without voluntary control.

Training the Will. — Voluntary actions are most effective when we act after the proper amount of deliberation. In

childhood we must learn to inhibit too hasty action. "Think before you act," is the maxim commonly taught to children, and with good reason. The child tends to act at once, on the mere perception of the situation. He must be taught to avoid impulsive action — that is, action in which the motor impulse follows immediately upon stimulation. Emotional expression (weeping, kicking, etc.) is restrained and controlled by admonition and punishment. The will to *refrain* is taught first; the will to *act* comes later.

In adult life, if restraint has been properly cultivated, the emphasis is on the other side. Too much deliberation leads to a vacillating attitude. We should cultivate the habit of sizing up the possibilities quickly and then acting without needless delay. The ordinary situations of life are clear enough for quick decision. Long deliberation is apt to lead to a habit of day-dreaming — of living in a fictitious world. Its pathological manifestation is *aboulia*, a condition where the patient is unable to reach any decision at all.

In popular psychology 'will power' means the capacity to go ahead and *keep* going ahead in a motor way. The strong-willed man is one who pushes his purposes to completion regardless of obstacles. He is not discouraged, whatever happens. Even physical pain, the greatest deterrent, will not turn him aside. We read of the Spartan boy who was gnawed by a fox which he had brought to school concealed in his clothing, and yet by sheer strength of will kept a passive countenance and showed no signs of his agony. As a modern parallel might be cited the American governor of Cuba, who stuck to his post and fulfilled his administrative duties faithfully for days, despite a raging fever.

These instances show the power of vivid thought (the *purpose* idea) to keep one steadfast in vigorous action or in self-restraint. He who is trained to control his actions by steady purpose and grit is best able to cultivate useful habits — and to break bad habits. If the thoughts 'I will' or 'I will not'

find strict motor obedience, one need not fear being overmastered by any habit.

Training the will gives us greater ability to resist suggestion. This does not mean that if some one advises us to do a thing we should promptly refuse. The majority of suggestions from those about us are probably reasonable and deserve consideration. But neither should we promptly acquiesce. Voluntary decision requires at least an instant of deliberation. If we fall into the habit of following a certain person's suggestion *without hesitation*, we become the agents of his will, not our own. This may have no bad effect on us if this particular person is conscientious and competent, so long as he is there to guide us. But when the master-mind is removed we are in sore difficulty if we have lost our self-reliance and power of self-guidance.

This is especially to be remembered in the home training of children. Parents who insist upon immediate, unreasoning obedience, are fitting their children to be the slaves of others. If the training is effective — if it makes the child perfectly docile — he will develop into a type of which his parents will not be proud. If he inherits the same 'masterful' traits which prompts them to treat him this way, he will rebel and the attempt will fail. Training in obedience, in conforming to social conventions, is an essential part of the child's education. But when he reaches the reasoning age, parents and teachers should not expect unreasoning obedience. It is the parent's duty to show the why and the wherefore of his commands, and to *cultivate in the child the spirit of challenge.* This seems the only way to avoid one of two unfortunate outcomes: either a hopeless obedience to suggestion, with a minimum of will-power, or an unsocial obstinacy.

Ideals

Nature of Ideals. — An ideal is a very complex experience in which ideas, systemic sensations, and motor sensations

are all prominent. It consists of a vivid image or thought, together with an intense feeling and a strong tendency to act. If one's ideal is to become a physician, he has a general image or thought of the various characteristics of the medical profession; he is stirred by a noticeable feeling when he thinks of what a doctor can accomplish; and his acts, with their accompanying motor sensations, are such as will tend to fit him to become a capable physician. In other words, an ideal involves thinking a thing, feeling it, and doing it.

Ideals generally grow up by degrees out of particular experiences in which one or other of these different elements predominates. Our deepest-rooted ideals are usually formed slowly and are related to a host of separate experiences. The experiences which develop into ideals are due largely to social stimulation. We are told that we are fitted for a certain career; or the ideal may be aroused by contact with some one who has been successful in this particular line of work, or it may be strengthened by meeting some one who has made a conspicuous failure in some other line that appealed to us as an alternative.

Ideals are of the utmost importance in human life; but their importance consists in their persistence and pervasiveness rather than in their vividness. They stick to us through thick and thin, but we rarely experience them as distinct and vivid states of mind. Usually they are marginal or subconscious. They are underlying *motives* of actions, and are usually noticeable only in the attitudes which we assume (ch. xv).

Summary. — The various kinds of behavior discussed in the two preceding chapters give rise to motor experiences. Muscular contractions stimulate muscle sensations; these and our static sensations are combined into experiences of our own activity. Motor experiences are divided into *conations* and *volitions*. A conation is a simple experience which accompanies reflexes, instincts, and fixed habits. It is usually vague and unimportant.

A volition is an experience composed of motor sensations and ideas; the ideas are *anticipation images* or purposes, which in the course of time are put into effect. The connections in the nervous system between the will-impulse and the appropriate movements are not inherited, but acquired. The special features of will are the *delay* (with deliberation) and *choice*. The actions which follow a volition are called *ideomotor actions*.

An *ideal* is a composite experience which includes ideas, feelings, and motor sensations. Ideals are rarely vivid; they usually form underlying attitudes, which are of prime importance in life.

PRACTICAL EXERCISES:

59. Analyze the motor experiences of laughter.
60. Describe the chain of experiences involved in picking up a book, especially the muscle sensations.
61. Test your ability to inhibit each of the reflexes in lists A and B, of Table X (p. 233). Also try which of them can be brought about voluntarily.
62. Examine your experiences when you are planning some course of action, such as how to spend a holiday.
63. Trace the development of your ideal of what your career should be.

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CHAPTER XIII

LANGUAGE AND THOUGHT

Communication. — So far we have considered a man's experiences as something belonging to himself alone, and as having no connection with the experiences of other human beings. As a matter of fact, the experiences of one member of the community frequently affect others very decidedly. Ideas are passed along from one individual to another. The communication of impressions has an important bearing on our mental development. In many cases we can shorten the process of learning considerably by the simple expedient of having some one else tell us what to do. " Keep your mouth closed and hold your head lower," says the swimming teacher, and the process of learning to swim is much simplified by the communication of these ideas.

There is a popular notion that one mind sometimes influences another directly, without the medium of the nervous system and receptors. There is at present no satisfactory evidence that this direct communication ever takes place. We get ideas from other persons by means of indications which they express in words or gestures; and these indications are always received through our ears or eyes or some other sense receptor. What one reads in popular magazines and novels about *telepathy* can be dismissed as highly improbable.

Communication is an important factor in mental life. It not only enables us to learn rapidly, but it furnishes us with a great store of ideas which no single individual could gather during his limited life-time by his own unaided efforts. Besides all this, communication and social intercourse are the means of building up two new sorts of experience: *language* and *thought.*

Language is an experience made up of the same kind of elements as volition. Both volition and language are composed of ideas and motor sensations. But language leads to a very different kind of response from volition. In the case of volition the response is some direct effect on the general environment; in language the response is some gesture or vocal expression which arouses an idea *in some other person* and brings him into relation with the speaker. Voluntary action enables you to open a closed door by turning the knob with your hand. But if the knob does not work, you call out, "Open the door," and this *language response* on your part may induce some one inside the room to turn the key and let you in. Language responses often bring about indirectly the same result that volitional responses bring about directly.

A *thought* is a special kind of idea which developed in the first place as an aid to communication. You may have a vivid memory of some event in your life; but unless you are an artist you cannot reproduce this in picture form for the benefit of others. You can only communicate it by means of arbitrary, conventional symbols. If you have seen the Natural Bridge and wish to describe it to a friend, you do so by means of visible symbols (by writing a series of words) or audible symbols — by saying 'bridge' and uttering other conventional sounds which call up corresponding ideas in his mind. Your friend reads your letter or listens to your description, and this arouses in him an idea of the Natural Bridge which is more or less like your own idea.

The sound of the word 'bridge' in no way resembles a real bridge; and the written word BRIDGE does not look like a bridge. But by repeated association between the spoken or written word and the object, the word calls up the memory image of the object, and in the course of time the word tends to replace the image, so that we represent the bridge in terms of words instead of by a mental picture of the thing itself.

Ideas whose prominent elements are words, instead of images, are called thoughts. Thoughts are arbitrary, conventional representations which take the place of mental pictures (images) of objects and events.

Language and thought belong to a higher level than other experiences. They involve the growth of several new adjusting centers in the cortex of the brain. These two types of experience, language and thought, grow up together. Speaking and thinking in words depend on the accumulation of traces in one or more of these special centers. If you speak a word you hear the sound of your own utterance, so that the spoken word is intimately connected with the thought-word. The greater the number of words in a language, the more acute is the thinking in the community using that language.

We find, then, that language and thought are composed of ideas and motor sensations; and that they have a number of peculiar characteristics, which are not found in the experiences noticed in previous chapters. (1) Language and thought depend on *communication* between individuals. Primitive man speaks with reference to some listener: he learns to think in words through repeatedly uttering words for *social purposes.* (2) Language and thought form a *higher grade* of experience than perception, memory, emotion, and the rest; they involve the development of *special centers* in the brain. (3) Language and thought are symbolic; that is, they are *arbitrary, conventional signs* — not mental copies of what they represent. Except in rare cases the sound and the written letter do not resemble the thing for which they stand.

Symbolic Experiences. — The last-mentioned characteristic distinguishes thought from other sorts of ideas. A memory is virtually a reproduction of some definite perception. Fancies and general images consist of bits gathered together from various perceptions. The distinguishing mark of a general image is that it reproduces in a sketchy way the appearance of some class of objects.

It would not be easy to draw pictures similar to our general ideas every time we wished to communicate with others; so instead we make some arbitrary sound or gesture which takes the place of the picture. A certain sound or gesture comes to be habitually associated with the idea of a tree, another with the idea of a man, and so on; through constant association the conventional sound or gesture tends to become more and more a part of the idea. Among civilized men this association is so strong that the arbitrary sound produced by uttering the word tree, for instance, becomes the chief element in our general idea of a tree. We think of trees chiefly in terms of the sound or vocal utterance of that word; the mental picture of the tree tends to become more and more vague. In this way thoughts tend to displace general ideas in our mental experience. Thinking is largely a series of word-pictures — not of object-pictures. We think in terms of words and sentences, which do not resemble the things we are thinking about. Words are arbitrary signs or symbols which we use instead of calling up the 'copy' every time.

Thought is an outgrowth of language. One can readily call up memories and general images of the things he has experienced. In all ordinary situations of life we could probably work out our ideas by means of mental pictures without using any symbolic terms. There seems no reason why a solitary man should have devised the words *tree* and *cow* to help him in thinking about trees and cows. The fact that some of us think aloud when alone is no argument; we are simply exercising a firmly established habit. There is evidence that castaways gradually lose the power of ready speech; their thinking probably reverts more and more to the 'image' type. It is social situations that lead to the invention of words, and to their use as ideas in place of imagery.

The Different Kinds of Language. — The principal kinds of language are *gesture*, *speech*, and *writing*. Each finds expression in a special type of behavior: gesturing makes use princi-

pally of the hands and head; speaking uses the mouth and throat; writing uses the hands and some instrument which leaves a permanent mark on stone, paper, etc. Facial expression is a more primitive type than any of these, but it is generally an expression of emotional states and is rarely used for communication. Winking an eye or smiling at some one may be treated as facial gesturing.

Gesture language probably arose earlier than speech. It came from the practice of pointing to objects or waving the arms to arouse attention. In time many of these gestures assumed a conventional form. Certain movements of the hand and head came to denote fish, fruit, meat, fire, cooking; pairs of opposite movements came to signify assent or dissent, or 'come here' and 'go away.' Gesture language is still used among the deaf. Otherwise it has been almost wholly superseded by speech.

Vocal language is much more convenient than gesturing. One can easily speak when engaged in fishing or plowing, while gestures are apt to interfere with these occupations. One can listen to oral conversation without turning the head; it is not easy to watch the plow and a companion's gestures at the same time. The ears are always open; we can secure a man's attention to what we say without stepping in front of him or seizing hold of him, — though some people do not seem to realize this. In the sick room gesturing may be more effective; but in ordinary situations speech has all the advantages.

The various languages or *tongues* which have grown up among mankind — Greek, English, French, etc. — all belong to the same mental type: vocal expression. They differ only in the special words that are arbitrarily associated with each object or meaning. Associations of ideas formed in early childhood are most likely to persist; so that if one starts life in an English-speaking community, the English word-associations are deeper rooted than those acquired later. A young

child may easily be taught three or more languages and remain master of them all. Later in life, verbal associations are more difficult to form; languages learned after the adolescent period are rarely so well organized or so thoroughly assimilated. It is not known whether each tongue develops a special center in the speech region; but we know that the associations between words of the same tongue are closer than between those of different tongues.

Written (graphic) language is used in civilized communities to supplement speech. It consists in making permanent marks or impressions upon stone, bricks, papyrus, or paper. In the older graphic languages the records were rude pictures of objects; later these pictures became conventionalized, as in Chinese, or each graphic unit came to symbolize a syllabic sound, as in syllabary Japanese. In the graphic language of modern western races each symbol represents an elementary vocal sound, either consonant or vowel. The letters of our alphabet are symbols for vocal sounds which are themselves arbitrary symbols for objects.[1]

There are several varieties of graphic language. Besides ordinary handwriting may be mentioned printing, typewriting, telegraphy, and phonography. In all these forms the characteristic feature is the permanent record, which makes it possible for one person to communicate with others at great distances or after long intervals of time. In fact the chief use of graphic language is to extend the range of communication in space and time. Graphic language, like gesture language, is received visually, except the phonographic variety, which is auditory.[2]

Nearly all graphic languages are asymmetrical. In the Greek and Latin alphabets the record always runs from left to

[1] Our numerals are not vocal symbols, but 'ideographs.' The number 1492 conveys the same meaning to all men, whatever their tongue.

[2] Books for the blind, printed in raised letters, are perceived by the sense of touch.

right, in Hebrew and Arabic from right to left, in Chinese from top to bottom. The order is practically never reversed, nor are individual letters turned around. ' Mirror-script ' is unintelligible to most persons, and it is usually difficult to write. [Fig. 76.] This is due to long fixation of habit; if you

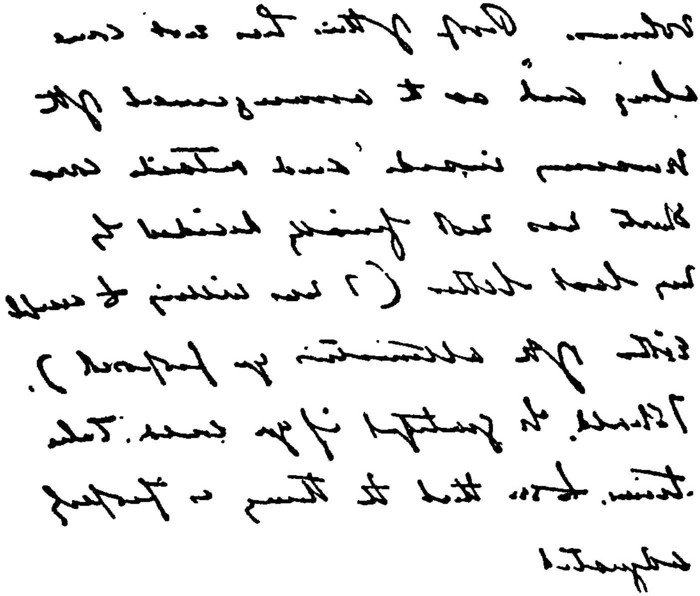

FIG. 76. — READING MIRROR SCRIPT

Unless one is practiced in reading reversed writing it is difficult to recognize and read a single word of this. Hold it before a mirror and the writing is plain.

practice sufficiently you can learn to write and read reversed script quite readily. The direction in which we write may possibly be due to the sort of instrument originally used by our ancestors in handwriting: a quill is more easily pulled along; a chisel is more effective when pushed; a brush is more naturally swept down toward you.

Understanding and Reading. — Communication is a two-sided affair. It is not completed, like other types of behavior, when the response is made; after the first person A speaks,

there is a receptive process on the part of another person B. The spoken words produce complex sound-waves, which stimulate B's ear. The effect of these verbal stimuli is very different from that of other sounds. There is first a *sound-perception* process in B's auditory center; then the nerve impulse passes into his auditory-speech (word-hearing) center, where *word-perception* occurs. This arouses in B a thought similar to the thought experienced by A as he utters the words.

The arousing of thought in a second person by speech or writing is called *understanding*. When B gets A's thought, he understands what A is trying to communicate. There is no special English term for receiving and understanding spoken words and gestures;[1] but the process of receiving and understanding written language is known as *reading*. Reading is more under our own control than the reception of spoken words. We can move the eyes slowly or rapidly so as to regulate the speed of receiving the stimuli; we can glance back and read a sentence over again.

In reading, the sensory elements are not prominent. We perceive the total word, not the individual letters. If there is an imperfection in one of the letters, we usually do not notice it, and often a wrong letter in a word passes unnoticed. Even the most expert proofreader may overlook these errors. The general meaning of the sentence suggests the thought, and if some letter or trivial word is omitted the imagination supplies the gap. The same is true in speech, though not to the same extent.

Our failure to detect such errors is due to the fact that understanding involves a *double* mental process, which almost smudges out the individual sensations. A word-stimulus is a sound or a visual effect. It is perceived like other stimuli; and just as in every kind of perception the piecemeal sensations merge into a general total effect. But after this there is

[1] It may be called *comprehension* or *listening*.

a further working over of the material in the higher verbal centers, which transforms it still more. This effect is noticed if we listen to some one speaking alternately in English and an unknown tongue. We get the same effect in reading if we come across some unknown foreign word or phrase. The unfamiliar words are heard or seen plainly, but they do not arouse ideas; they are merely sounds, or marks on the page.

Reading aloud is a further complication of the communication process. The reader acts as a *relay* between the author who expressed the thought originally, and the persons who receive it. It is quite possible for you to transmit thought without understanding it yourself, if you read aloud in an unknown tongue. You can even learn to read aloud mechanically in your own tongue, thinking of other things all the while, but giving the right accent and intonation to the sentences.

Brain Centers for Language and Thought. — There are four special brain centers concerned in language and thought: (1) a word-uttering or speaking center for vocal language; (2) a word-writing center for written language;[1] (3) a word-hearing center for understanding word-sounds and for auditory thought; and (4) a word-seeing center for reading and for visual thought.

These centers are found in only one side of the brain — usually the left side — whereas the other centers are found in both hemispheres.[2] The location of these four higher centers is shown in Fig. 77.[3] The word-hearing center lies near the auditory center in the left temporal lobe of the cortex; the word-uttering (speaking) center lies in the left frontal lobe

[1] It is possible that the 'gesture' center is distinct from this.

[2] In cases of paralysis, if the left side of the body is paralyzed the individual's capacity for thinking and speaking are usually quite normal; but if the right side is affected some of the language functions are apt to be impaired. The right side of the body is controlled by the left side of the brain.

[3] *Cf.* Figs. 13, 14. Recent investigation indicates considerable individual differences in the location of these centers.

near the region which controls movements of the tongue, lips, and throat. These two regions are connected together by association tracts. Vocal language ordinarily involves co-operation of the two. If the word-hearing region is destroyed the patient is unable to understand the meaning of words,[1]

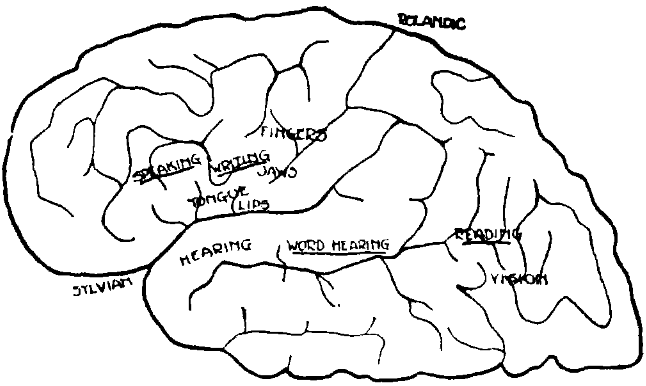

FIG. 77. — LANGUAGE CENTERS IN THE CORTEX

Diagram of cortex of the left hemisphere; front of the head is at left of the drawing. Speaking or word-uttering center is in frontal lobe near centers for moving tongue, lips, and jaws. Writing center is near centers for moving fingers. Word-hearing or auditory language center is in temporal lobe near the center for hearing. Reading or word-seeing center is in occipital lobe near the visual center. (Cf. Figs. 13, 14.)

though not deaf to sounds in general. He may be able to utter words through other connections. If the word-uttering center is destroyed the patient is unable to speak, though he may understand the meaning of words. This disorder is called *motor aphasia*.

In the case of deaf persons who have been taught to speak and to 'read the lips,' a connection is developed between the word-uttering center and some center in the visual region. The popular term *deaf-mute* is incorrect. A deaf man is mute merely because the connections between lip-word seeing and word uttering have not been trained. These connections are harder to form than between hearing and uttering

[1] This disorder is called *sensory aphasia*.

words, but under proper treatment they can be readily developed.

The word-seeing (reading) center lies near the visual region in the occipital lobe of the left hemisphere. Destruction of this area causes inability to read (*alexia*). The patient sees the letters, but they do not convey any meaning to him, — just as an Arabic or Chinese inscription appears to us only as a miscellaneous collection of marks. The word-writing center lies in the frontal lobe near the center which controls hand and finger movements. Its destruction causes inability to write (*agraphia*). These two centers are not so closely connected as the two vocal-speech centers. Destruction of one function is not so likely to involve disturbance of the other. In fact the word-seeing center is more closely connected with the word-uttering center than with the word-writing center.

The Different Kinds of Thought. — The ideas of civilized man consist largely of verbal thoughts. For most of us the *word* 'horse' is the main feature of our idea of a horse. We picture vaguely the appearance of horses, their movements, the sounds they make in galloping or neighing; but the focus of the idea is the word.

For some persons a word is chiefly a *sound*. For others it is the *muscle sensations* from the lips, tongue, and throat in speaking. For others it is the *looks* of the printed word. In a few cases it may be the muscle sensations from the *hand* in writing. So there are these four different kinds of thinking: auditory, vocal-motor, visual, and hand-motor. We classify people according as their thinking belongs to one or other of these types. But in many cases a man's thinking may combine two or more of these elements: your thought of a horse may include both the sound of the word and the motor sensations of uttering it.

When you think in terms of the sounds, the word-hearing center is the seat of the nerve activity; if you form the words in your throat, the nerve activity is in the word-uttering

center. In the vocal type of thinking, the thought is usually not expressed aloud; there is merely a slight muscular adjustment which is not detected except by very delicate instruments.[1] Individuals of the 'visual' type, who think in terms of the looks of printed words, use the reading center in thinking. The destruction of any one of the four special centers leads to disturbances of thought as well as of language. This is why aphasic patients of certain types often break off in a sentence and seem to lose track of their thoughts.

Meaning and Value. — Although thoughts are symbols, every thought contains certain elements which resemble the object or situation we are thinking about. These " bits of the real thing " make up the *meaning* of the thought. When we think of *man*, the arbitrary *word* ' man ' is the central feature or focus of the experience. But at the same time there is somewhere in the background or margin of the thought a fleeting image of some particular man or of certain human characteristics. These faint images constitute the meaning. In other words, the meaning of a thought comprises those elements in the experience which correspond to the object or situation, as distinguished from the mere verbal or symbolic elements. When you try to examine the meaning of a word, by observing it closely, what happens is that these marginal elements become prominent. This occurs very notably in scientific and logical thinking, where the meaning is especially important. On the other hand, if you take a familiar word and repeat it over and over again (man-man-man-man . . . . .) it finally loses all meaning: the sound becomes so insistent that the image elements disappear altogether.

The *value* experience is the same sort of thing as the experience of *meaning*, except that it has to do with intensity and quantity. Your thought of a book is usually tinged with some idea of its being thick, long, heavy, difficult to read, true — or the opposite of these. In most cases these ideas

[1] These slight vocal adjustments are called *implicit* responses.

are vague and only form part of the margin of the thought. They make up its *value* tinge. But if we attend closely to some quantitative characteristic of an object, this value element comes to the foreground; we get a rather new sort of experience — the *idea of value.* The value idea is especially prominent in sentiments (ch. ix); a belief is partly an idea of the worth of some statement, partly a feeling.

The same experience may have very different values attached to it at different times. When Newton saw the apple fall, it probably seemed a trivial occurrence. Afterwards, as he thought about it more carefully and formulated the law of gravitation, the experience acquired a meaning and a value hitherto undreamed of.

Psychology investigates the nature of our experience of value, but it has nothing to do with finding out the real value of things. Logic determines what is true; esthetics shows what is beautiful; ethics teaches what is good. These sciences enable us to adjust our valuation of situations and events to the ' objective values ' of the world about us. One might almost regard them as instances of applied psychology.

This distinction brings out an interesting peculiarity of the psychologist's attitude toward social relations. Psychology is just as much concerned with faulty logic and bad conduct as with their opposites. The psychologist knows that in each case the error is due to something in the man's nature. He does not *approve* of immorality, but he treats it as a *fact* to be studied carefully and dispassionately. When he comes across an instance of wrong-doing he does not proceed at once to reprove or punish; his first duty is to determine where the trouble lies. Often this suggests a remedy which avoids the need of punishment. A child may lie because he does not appreciate the distinction between memory and imagination; he may be disobedient because his attention has not been trained to listen to what you tell him; he may be quarrelsome or obstreperous on account of digestive disorders. In short,

it is the business of the psychologist to try first of all to understand the situation which led to these breaches of ethics. The practical result of this attitude is seen in the recent improvement of the methods of handling delinquents and criminals, which is attributable in no small degree to the work of psychologists.

Rational Thought and Rational Behavior. — As human thinking progresses, the meaning and value elements in thought become more prominent and at the same time the meaning of familiar words tends to become stereotyped. When you think of a horse, the meaning of your thought includes certain definite characteristics common to all horses. When you try to make your thought correspond as nearly as possible to what horses really are, the more trivial associations fade away; only those remain which are characteristic or significant. In the same way the value elements in your thoughts tend to conform to the real values of the objects. A horse is larger than a man, smaller than an elephant. A thought which includes, besides the word, only the *really characteristic elements* of meaning or value, is called a *concept.* A concept is a special type of thought which tends to be " true to life."

A *judgment* is a thought which combines two concepts. If we combine the concept of a horse with the concept of a vertebrate, we obtain the judgment, " Horse — vertebrate," — or, as it is expressed in language, " A horse is a vertebrate," or, " All horses are vertebrates." When we think of a certain light and of its intensity, and combine the meaning with the value, the resulting thought is the judgment, " This light is bright."

Concepts and judgments are *rational thoughts.* They are distinguished from ordinary thoughts by their greater precision and by their close correspondence with real things. Our ordinary thoughts grow up in haphazard fashion. They contain irrelevant elements tacked on from casual associa-

tions. Your casual thought of a harbor may be associated with docks and your thought of a lake with islands. Neither of these associations is characteristic. As your experience broadens they fade away; your *concept* (rational thought) of a harbor does not include docks, and your concept of a lake does not include islands.

Since thought is closely bound up with language, rational thought has led to special sorts of verbal expression. The language equivalent of a concept is a *term;* the equivalent of a judgment is a *proposition.* The judgment ' horse — black ' may be instantaneous, but the proposition takes time; it starts with one term and the other term comes afterwards. This involves a succession of experiences (ch. xiv).

Rational thought assists us tremendously in handling real situations. Pure fancy, as aroused by fairy-tales for instance, is a source of enjoyment in our leisure hours; but it does not help us to meet the problems of real life. The more closely our thoughts correspond to actual situations in the world about us, the more appropriate our responses are likely to be. Behavior based on rational thought is *rational behavior*, which is a stage higher than ordinary intelligent behavior. Any action that is brought about by individual acquisition is *intelligent* behavior; an action is *rational* only if it is brought about by rational thought. The higher animals act intelligently, but they do not act rationally, because their behavior is not guided by thought. A human child begins to act rationally as soon as he acquires thoughts with definite meanings. Rational thought and rational behavior are often called *reason.*

The popular notion of reason is wrong in making it a special faculty of the human mind. It is not a brand-new mental endowment, but an outgrowth of more fundamental experiences. Mental development is one single continuous process from the simplest type of stimulation and response to rational behavior. There is no break, no sudden jump.

There is also a popular notion that human reason is infallible. As a matter of fact it is quite liable to make mistakes. Our direct information concerning the world is obtained through our senses. This information is put together (integrated) by combining sensations into perceptions, memories, and thoughts. Any misinformation may be corrected even apart from reason by cutting out chance associations and broadening our outlook on the world. Rational thought is merely the final focusing of the picture.

On the other hand, if our perceptions are wrong, even reason may be unable to correct the impression. In ancient times the most rational concept of *the earth* was of a flat, solid body, surmounted by a transparent dome, in which the stars were fixed. The rational judgment of *matter* was that it consisted of four elements — earth, air, fire, and water. Many of the rational thoughts of antiquity have been found *not to correspond to actual conditions;* — and many concepts and judgments accepted to-day are doubtless just as false. Rational thought furnishes merely our nearest approach to the truth.

Importance of Language and Thought. — It is scarcely possible to exaggerate the importance of language and thought in the mental life of man. They lead to two new kinds of behavior, *communication* and *rational behavior*, which carry us to a higher stage of mental life than the trial-and-error way of learning. Taken together, language and thought provide a tremendously effective means for adapting our responses to the general conditions of the environment.

More than any other type of experience, except perhaps emotion, language and thought must be studied in the light of their history. But emotion is a survival from ancestral conditions, while language and thought are recent human acquisitions. They are still in the making — still improving.

A noticeable feature in the growth of language is its slow evolution in the race and its rapid development in the indi-

vidual. New words are invented gradually, as the sphere of thought in the race enlarges. Once adopted they are transmitted rapidly to the bulk of individuals in the community; each child acquires a large vocabulary at an early age.

Much the same is true in regard to thought. The growth of thought depends upon the existence of words. If the vocabulary of a community is scanty, the range of thought is limited. Given a rich vocabulary, the mentally well-developed individuals in the community quickly attain a wide range of thought.

The development of language and thought in the individual depends not only upon the social environment, but upon inherited nerve structure. In order to speak (to use vocal language) we must possess inherited pathways between the word-hearing center and the word-uttering center. Writing involves countless pathways between the word-seeing or word-hearing center and the word-writing center. It is because of the great masses of association fibers present from birth in the human cortex, that man's intellect is so vastly superior to that of any other species. Within the human species it is the sphere of thought, more than any other department of mental life, that reveals the greatest individual differences in capacity and attainment. This is especially true of rational thought.

Training of Thought and Language. — The highest stage of general education is largely a training of thought and of the rational processes that grow out of it. If primary education teaches us to *perceive*, and secondary education teaches us to *remember*, college education should teach us to *think*. This special objective is often overlooked by both instructor and student. Too much emphasis is laid on imparting mere facts, and on retaining them — till after the final examination. It is far more useful to know how to *think about* the facts, — to understand the principles of whatever branch we are studying. You can readily find the value of the gravity factor g in

your physics book. It is more useful to understand such principles as the elliptical motion of planets. In psychology it is much more important to get the right notion about the 'learning process' than to memorize any of the tables or definitions in this book.

The training of thought means especially the cultivation of *rational* thought — of clear thinking, as it might be called. The best way to accomplish this is to *ponder;* — not to memorize, in an effort to retain, but to seek out the connections between the facts. Try to picture the relations step by step. Practice makes the process continually easier.

A practical problem in education is whether to cultivate 'visual' or 'auditory' thinking. Some students master a subject better by reading, and others by listening to lectures. (So-called mental arithmetic is really auditory arithmetic.) Both methods should be cultivated, because both methods of imparting knowledge are constantly used in modern education. Text-books give the main principles; the difficulties that strike any individual student are better overcome by word of mouth. An important point is to learn to suppress the motor type of thinking. You will read more quickly — and understand quite as well — if you learn to suppress the incipient tendencies to utter the words or to form them with the lips and throat. Such motor accompaniments act as a drag in reading, and they rarely make the thought more clear. Their only real use is to focus your wandering attention when you are tired or the subject is uninteresting.

Psychology is not especially concerned with vocal enunciation, except that stuttering and faulty pronunciation often indicate faulty coördination in the brain centers. Psychology is more interested in diction. Certain types of sentence, the use of certain words, indicate clear thinking. Faulty grammatical construction and the use of incorrect words or vague phrases indicate slovenly habits of thought. It is often a help to the student for the teacher to ask, " What do

you mean by this sentence (or word)?" The very challenge may lead to clearer conception.

An important problem in education is to teach the child to maintain a proper balance between language and thought. The contemplative, silent man overemphasizes the thought side and is inclined to be unsociable. The voluble man dresses his thoughts in public, instead of within the private chambers of his own mind. It is the task of the educator to subdue the chatterer and draw out the reticent one. To successfully attain a happy mean, this training must be begun early in life.

Higher and Lower Levels of Behavior. — Language and thought, as we have seen, involve a higher sort of behavior than other types of experience. Their relation to the two lower levels of mental life is shown in the accompanying diagram. [Fig. 78.]

(1) LOWEST NERVOUS ARC: From the various receptors the sensory nerves lead first of all to the *primary centers.* There are numerous primary centers in the cord and in the lower part of the brain; but in the diagram, for simplicity, they are grouped into three headings: external, systemic, and motor-sense centers. From these primary sensory centers the nerve impulse may pass over directly into one of the primary motor centers (shown at the right of the figure), and from there pass down directly to some muscle or gland or over into the autonomic system. This lowest nervous arc gives *reflex actions*, the simplest type of behavior.

(2) INTERMEDIATE NERVOUS ARC: From the primary sensory centers, paths lead up to the cortex, and to the various centers there. These secondary or intermediate centers are active in our experiences of perception and imagery, feeling, emotion, and volition. They are closely interconnected, so that a whole chain of experiences may succeed one another before any important motor impulse is started (ch. xiv). But sooner or later the nerve impulse passes over to some

secondary motor center, and from there an outbound impulse goes out to the lower motor centers and thence to the effect-

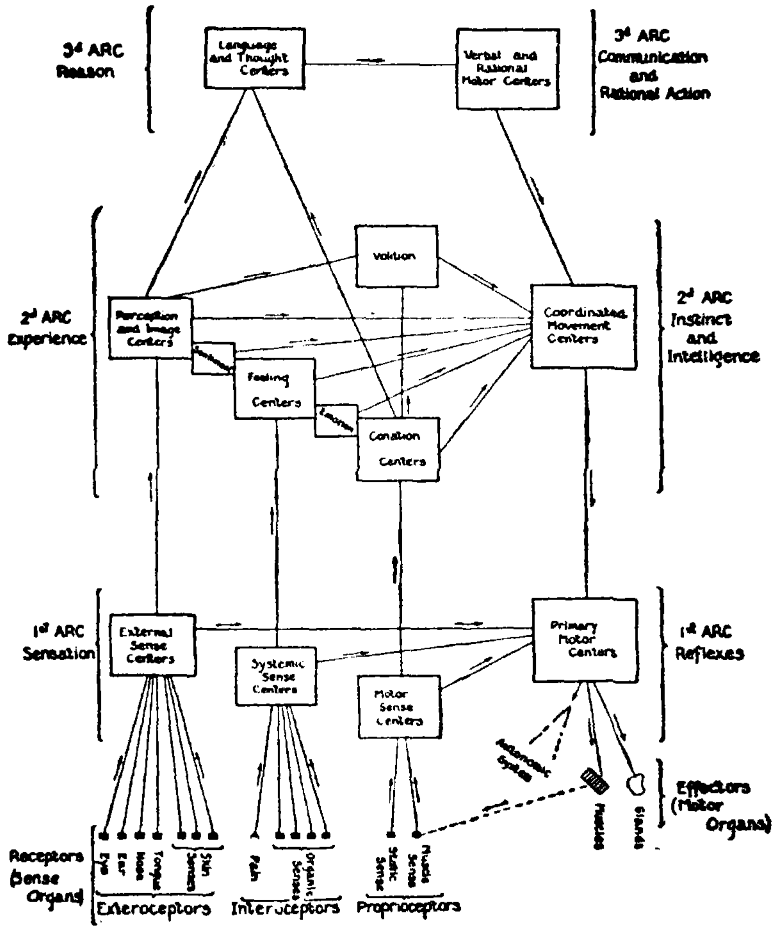

FIG. 78. — MENTAL LEVELS

Diagram showing the three levels of nervous arcs and the grade of mental life corresponding to each level. Arrows indicate direction of nerve current. Broken lines (below at right) indicate that motor expression stimulates muscle sensations. The centers are shown very schematically; e.g., many separate centers are included in square labeled "external sense centers."

ors. The movements resulting from these second-level motor impulses are coördinated; they differ in this respect from

simple reflexes. The operation of the secondary nervous arc gives *instinctive* and *intelligent* behavior — usually a combination of the two.

(3) Highest Nervous Arc: In man a third set of centers and a tertiary nervous arc have developed. Impulses from the second-level experience centers, instead of going over to the motor centers directly, may pass up to the centers for thought and language. From these centers the nerve impulse passes over into the verbal and rational motor centers and then down through motor paths to the lower motor centers and out to the effectors. This highest level of behavior has two different forms: *communication* and *rational action.*

The development of the two higher levels of the nervous arc is accompanied by more perfect adjustment of the responses. The behavior is more controlled, and more suited to the 'entire situation' than the simple reflexes. Rational behavior is much more adaptive and controlled than ordinary intelligent or instinctive behavior.

Summary. — In chapters vii to xiii we have examined the various kinds of experiences which are found in man. *Perception*, *memory*, and *imagination* are built out of sensations which we receive from the world around us; *feelings* come from systemic sensations; and *conations* from motor sensations. There are also experiences derived from two sources: *emotions* are built up out of systemic and motor sensations, *sentiments* out of systemic sensations and ideas, *volitions* out of motor sensations and ideas. There are also experiences called *ideals*, which are derived from all three sources.

The highest types of human experience are *language* and *thought*, which are brought about by a third level of nervous arc and involve four special centers in the brain.

All these kinds of experience are different ways of putting together (integrating) the information brought in over the sensory nerves. Their real significance in psychology is their

relation to behavior. Our responses are more suitable according as the stimuli are more completely integrated — that is, as our sensations are organized into *definite experiences.*

PRACTICAL EXERCISES:

64. What constitutes your thought of school, idiot, orchestra, Egypt, steamboat, thunder-storm, medicine, penitence?
65. Ask some one to read aloud, and at the same time to think of other things; note how far the distraction interferes with his pronunciation and especially with the vocal inflections which "give the sense."
66. Take two similar problems in physics, geometry, or some other science. Read one to yourself and have a friend read the other aloud to you. Compare your experiences in "understanding the problem" by the two methods.
67. Ask some one to prepare a typewritten page with many typographical errors. Read the page rapidly, checking the errors noticed. Read again carefully and observe what mistakes have escaped you. Do you notice errors better if they *look* like the right word but sound different (e.g. though and thought) or if they *sound* like the right word and look different (e.g. right and write)?
68. Observe the speech of a two or three year old child. Report any notable mistakes in pronunciation, grammar, misuse of words, and suggest the explanation of these errors.

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CHAPTER XIV

MENTAL SUCCESSION

The Stream of Consciousness. — Thus far we have considered detached, isolated experiences and responses. But this is only part of the story. In reality our states of mind are not completely separated from one another. Mental life is not a series of independent happenings. Each experience and each act is affected by our past experiences and actions.

Human actions are rarely instantaneous. The response to a given situation often involves a long series of actions, one step leading to the next. If one step is cut out or if the order of procedure is inverted, the action may be quite ineffective and even absurd. You must load your gun before you press the trigger, and thread your needle before you begin to sew. For the most part behavior is a continuous process, not a series of detached reflexes. Each step passes gradually into the next.

Our mental life, with its various experiences and actions, may be likened to a stream which flows steadily onward, moment by moment, day by day, year by year, bearing on its bosom ships and cargoes of various sorts. We often speak of the 'flow of thought' and the 'flow of language.' It is not so common to speak of the flow of perceptions or feelings, but these and all other experiences flow along in much the same way. James calls this general flow of experiences the *stream of consciousness*. Our conscious life at any instant is a cross-section of the stream. The present cannot be fully understood except by reference to what has gone before. Underlying the thoughts and perceptions of conscious life is the stream of nerve impulses which course through the brain, rousing now one experience, now another, in endless succession.

The simile of the stream helps us to picture the 'flow'

of life. In other respects it is imperfect. Our experiences are not uniform like a stream of water. Perceptions are quite different from thoughts; and these two types of experience flow along in very different ways. The flow of perceptions is controlled largely by the succession of *stimuli* that happen to affect us, while the flow of thoughts, memories, and images is determined almost wholly by conditions in the *brain*. There are really two different currents in our mental life, or (better) two separate strands which interweave to form the texture of experience.

Speed of Thought; Reaction Time. — How rapidly do our experiences flow? Popular notions on this point are quite vague. Fanciful stories are told of drowning men who live over their entire lives in a few minutes. We hear of dreams which involve a long succession of events lasting a year or more, ending with the crashing of a real mirror which wakens the sleeper — the whole dream having presumably been started by the crash itself. Such stories lead to wrong ideas of the duration of our experiences. The terror of drowning may arouse many memories which had lain dormant for years, and may speed up the flow of thought considerably, but there is a limit to the speeding-up process. In the mirror dream the experiences probably came in the form of an instantaneous picture; the background of the picture was an illusory memory, in which the dreamer seemed to have lived over the events successively. There is undoubtedly a slip somewhere in all such stories — either an exaggeration of the *number* of experiences involved or a *wrong interpretation* of the experience itself.

The rate of change in perceptions and thoughts is limited by the rate of conduction of the nerve impulse. The highest velocity of nerve impulse so far discovered by physiological experiment is about 400 feet per second. The resistance at the synapses causes delay, and this lengthens the time of passage from neuron to neuron.

Having found this physiological limit, the next step is to determine in how short a time a simple mental act can be accomplished. This has been determined by experiments in the laboratory. A stimulus is given — a sudden flash of light or a noise; as soon as the subject perceives it he presses a key. By means of electrical connections the stimulus starts the hands of a chronoscope [Fig. 79], and the pressure of the keys stops them, so that the duration of the entire stimulus-response process is accurately measured. This duration is called *reaction time*. If the subject has been trained to react to the stimulus as quickly as possible, the reaction time represents his utmost speed for this particular kind of perception.

Reaction time is divided into three periods: (1) Sensory conduction from the receptor to the brain center. (In this period is included the time required for the stimulus to excite the receptor and sensory nerve.) (2) Central processes. In simple reactions this period is devoted to the mental process of perceiving; but in complicated experiments certain other central processes, such as discrimination or association, take place before the motor impulse starts. (3) Motor conduction of the nerve impulse from the brain to the muscle, together with the time needed for the muscular contraction to take place.

Although the rate of nerve conduction is approximately known, the duration of the two conduction periods is not completely determined, because we do not know how much time is required for the impulse to pass through the synapses nor the length of the reception and muscular-contraction periods. Visual reaction, for example, is found to be considerably longer than auditory or tactile reaction, probably because the eye takes longer to receive its stimulus than the ear or the touch corpuscles. There is also found to be considerable difference in the reaction times of the same person according as his attention is fixed on the stimulus (sensory reaction) or upon the movement (muscular reaction). While

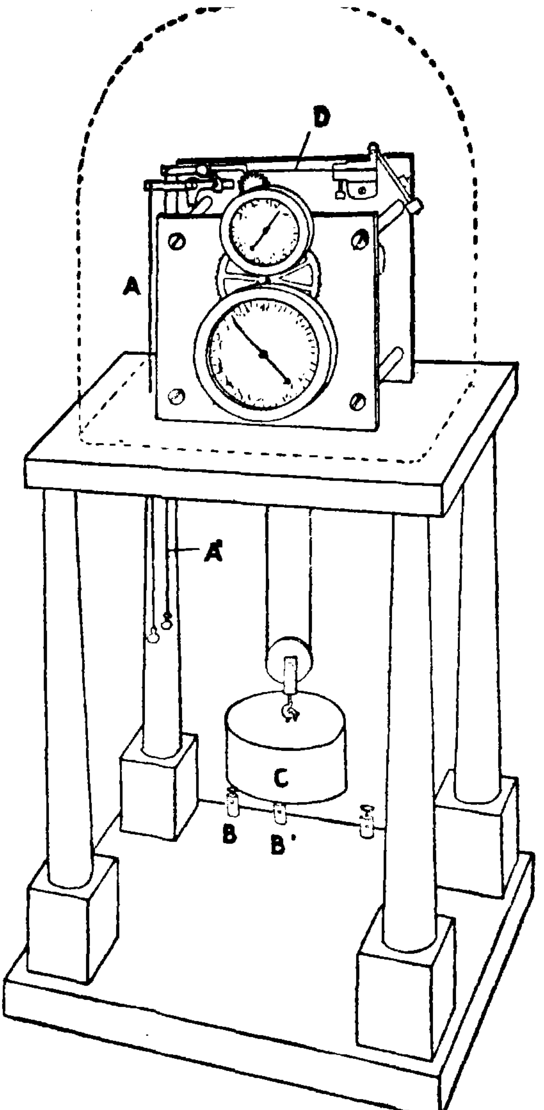

FIG. 79. — HIPP CHRONOSCOPE

Instrument used for measuring reaction time. Each dial is divided into 100 units. Upper dial measures thousandths of a second (0.001 second = 1 sigma); lower dial measures tenths of a second. Clock-work (behind the dials) is started and stopped by pulling the cords A, A′ at left; hands do not move till an electric current meshes a cogwheel (back of upper dial) into the clock-work. The wires of the circuit are joined with the Hipp at binding posts B, B′. Circuit is made when the stimulus is given, and broken when the subject reacts by *pressing* a key. Weight C furnishes motor power for clockwork; the speed is governed by vibrations of a small reed D, which vibrates over a cogwheel.

there is considerable variation between the reaction times of different individuals, the figures given in Table XIII represent the average perceptual reactions of trained subjects. The unit of measurement is the thousandth part of a second, which is called a *sigma* (σ).

TABLE XIII.— REACTION TIME OF PERCEPTION

Stimulus	*Sensory Attention*	*Muscular Attention*
Light	290σ	180σ
Sound	225	120
Electric on skin	210	105

[From Titchener, *Text-book*, p. 432.]

If the observer is directed to perform some mental act in addition to perception before he presses the key, the experiment measures *complex reaction time.* The experimenter may show in turn a number of different colors in chance order, and require the subject to *recognize* the color before pressing the key. Or the subject is required to press one key for blue, another for red, and so on. This is *discrimination* reaction time. In any complex reaction the conduction time to and from the center is the same as in perception reaction, so that the increased duration of the reaction represents the time required for the *additional mental process.*

Titchener found in his own case that recognition of a color required 28σ longer than simple visual reaction. His recognition time for a letter of the alphabet was 51σ and for a short word 45σ. These relations hold generally, though the absolute times vary for different persons; it requires less time to recognize a word of three letters than a single letter.

Experiments have been made on the time required to associate one thought with another. The stimulus is a printed or spoken word. When the observer sees or hears the word it arouses a thought in his mind; he is directed to react just as soon as this thought suggests another idea. The experiment may be safeguarded by having the observer react by speaking the word aloud instead of pressing a key; the

voice strikes a sensitive membrane, whose vibrations press a small hammer so that it makes the electric contact. In a series of over 6000 auditory association reactions on 22 persons Wreschner found that the average *association* reaction time was about 2000σ (2 seconds).

The experimental investigation of reaction time has not fully solved the problem of the rate at which our experiences follow one another. Slight changes in perceptions may take place much more rapidly than the rise of new perceptions; thoughts may be modified in some of their details more quickly than a brand-new association can be formed. But just as light has a limiting rate of transmission, so we are certain that thought and perception have their speed limit. 'Quick as lightning' does not mean 'instantaneously'; neither does 'quick as thought.'

The Stream of Perceptions. — A large portion of our experiences are the direct result of stimuli outside our body. These stimuli are changing constantly, and give rise to a *stream of perceptions*. Our mental life often consists for a long time of a series of perceptions, uninterrupted by any notable experiences of other sorts. We may see, hear, 'palp,' and 'heft' the things about us without being affected by any striking emotion, and without having any definite thoughts or memory pictures.

The succession of these experiences depends primarily upon conditions in the environment. Stimuli which affect our eyes, ears, skin, and nostrils are due mainly to forces outside our own body, which are for the most part independent of our will. We do not control the flow of perceptions in the same way that we control our own movements, feelings, and ideas.

I can readily arouse a thought of my brother; but I cannot arouse a perception of him if he happens to be a hundred miles away. You can arouse the memory of a rose and the feeling of pleasure at its form and odor; but you cannot get a per-

ception of its form or a sensation of its odor if there is no rose present to stimulate your eyes and nostrils.

Our ability to control our perceptions is mostly by way of prevention — not production. We can reduce a perception to the margin of consciousness by attending to something else; we may get rid of it entirely by closing the eyes or walking away. Often we modify a perception by adding images or thoughts, so that a tree seen in the dusk becomes a bird or camel. But we have little power to produce any desired perception at will. The ultimate source of perception lies in the world outside us.

The succession of perceptions is determined by the following factors:

(1) External stimuli and their changes.

(2) The manner of stimulation. We see an object differently according as we look at it with the center of the eye or the periphery.

(3) Retention of the effect of similar stimuli that occurred in the past. Repetition and retention improve one's ability to pick out certain stimuli and combine them into perceptual states.

(4) Systemic and motor stimuli which occur at the time. Excitement, pain, distaste, pleasure, may inhibit certain perceptions and emphasize others. Motor stimuli and the resulting motor activity enable us to get rid of certain external stimuli and substitute others.

Of these four factors all but the first are conditions within our own body. Yet the external factor is the great determining condition of perception and outweighs in importance all the others combined.

The Stream of Thought. — The mental life of civilized man often includes a long succession of memories, images, and thoughts uninterrupted by perceptions. The starting-point of such a series is always a perception or some other sensory experience; but the train of ideas, once started, may proceed for a long time without interference.

In subhuman species prolonged trains of ideas apparently do not occur. If an animal has a memory or any other image, it either leads directly to motor expression or is quickly followed by some new perceptual experience. A dog gives evidence of remembering his master after prolonged absence, but instead of this memory starting a train of reminiscences, it leads at once to barking, frisking about, and vigorous wagging of the tail. Even while the memory image lasts it may be interrupted by a word or a gesture from his master, which starts a new sensory experience. In lower animals memory is even more fragmentary.

In man imagery, and more especially thought, tends to become one of the most important phases of mental life. A perception arouses a thought, this thought excites another thought, this in turn a third, and so on. A long series of thoughts may arise in quick succession, each independent of external stimulation except at the very beginning. Such a train of thoughts is called *thinking*.

For example, you hear a certain humming noise and think of an airplane. This suggests the thought of the airplane post, then you think of crossing the Atlantic, then of a great Atlantic liner, of the amount of coal consumed in a steamer, of mining coal, of a miner who became a clergyman, of revival services, of gospel hymns, of a boy choir, of the Boy Scouts, of one of your boyhood games, of a certain school teacher, and so on through a long series of thoughts.

The succession of mental images and thoughts is commonly called *association of ideas*. It is the same process that we examined under Recollection (ch. viii). Recalling a memory is merely a special case of calling up any image or thought; in fact, when the memory we want does not come immediately we usually have a long succession of other ideas.

The principles which were enumerated as 'laws of recollection' are fundamental laws of the association of ideas: (1) Law of Similarity and Contiguity. The idea aroused by

association is partly *similar* to the one preceding it, and the remainder consists of experiences that were formerly experienced *near* it in time and place. (2) Law of Frequency, Original Vividness, and Recency. As between different possible associations with a given idea, that one is most likely to follow which has occurred most *frequently*, or which was originally most *vivid*, or which has occurred most *recently*.

These laws of association are not arbitrary; they depend on the activity of the nerve impulses in the brain. In passing from center to center the current always follows the path that offers least resistance. The resistance is diminished by the retention of the effect of former impulses in various centers; similarity, contiguity, frequent repetition, original strength of impulse, and recency of excitation, are factors which determine the relative degree of resistance of several possible pathways; they determine which way thought will jump.

In addition to these principal factors which determine the course of a train of thought, there are certain secondary influences. Our general bodily condition often plays an important part in determining the direction of our thinking. If our digestive organs are working well, our thoughts are likely to dwell on pleasant subjects and the things we expect to accomplish. If we are dyspeptic we are prone to think of difficulties and annoyances. So, with the same thought as a starting-point, we may proceed along two entirely different lines of thought according to the different systemic stimuli that we are receiving. The reproductive organs affect our thought trains in the same way. In adolescence thoughts tend to be directed at times rather persistently toward sexual matters; in later life this tendency may vanish of its accord. The influence of stimuli from the respiratory and circulatory organs on thinking is less marked than that of the other internal systems.

Another secondary influence on the direction of thought is our general view of life and the special interests that appeal

to us. The trend of a person's life determines his attitudes (ch. xv), and his attitudes determine very largely the direction of his thinking. One man's thoughts run to money, another's to athletics and sporting subjects, and so on. We are not likely to notice this in ourselves, but if we meet one whose interests are quite different from our own we are often amazed to see how persistently he turns the conversation toward his own special interests and away from the channel of our own thoughts. Fixed ideas are an exaggerated and usually pathological form of this tendency. Certain insane patients persist in thinking that they are followed by enemies; their thoughts always hark back to this fixed delusion.

All these secondary influences which determine the direction of thought may be summed up under a single principle, the *Law of the Personal Equation:* As between different possible associations with a given idea, that one tends to succeed it which carries most interest to the individual or is most in keeping with his present systemic condition.

Control of Thought. — Thoughts are not the direct result of external stimuli. The first thought in a train may be due to something we see, hear, or read, but those that follow depend chiefly on processes within the brain itself. To this extent thinking is 'free'; our thoughts are not driven into us by external forces, like our perceptions. We ourselves determine their course in accordance with the principles of association.

We may direct our thinking along certain lines by taking a definite attitude and holding a given problem or goal before us. You wish to recall a certain name, and this desire attitude may direct the course of your thinking for a long time. You have the notion of a half-complete invention, and proceed to work out the details in thought. You are called on to solve a mathematical problem or arrange a concert, and you think over various possibilities till the best solution or program appears in thought. In all such cases the direction and

to some extent the material of your thought are under your own control.

Thinking may also be controlled indirectly by motor acts. You tie a knot in your handkerchief, or before going to bed you hide a stocking. The sight of the knot or the absence of an important article of apparel suggests to you the particular thought that induced this unusual action. The association is more direct when you place in your hatband a letter to be mailed. A written memorandum — 'draw money,' 'see Smith,' 'return umbrella' — is still more effective.

Sometimes a thought leaves a trace in the nerve structure which arouses another thought long afterwards. A friend asks you to dine at his house next Wednesday. The thought makes a vivid impression, and is gone. But Wednesday afternoon it somehow reappears — you remember the engagement. (Not always, unfortunately!) These retention traces seem to be impressed on the lower centers and to be in some way connected with our subconscious life. This is indicated by some of the phenomena of sleep and the hypnotic state. You determine to awake to-morrow morning at 6:30. If you are practiced in the art, you actually *do* awake at almost exactly that hour. The controlling medium here is subconscious.

All these mental and behavior operations are means by which an individual controls his own thinking. Thinking is at once 'free' and 'determined.' It is not compelled by outside forces, but it follows definite paths determined by the make-up of our nervous system and by the attitudes built up through our entire past experience.

A train of thought once started continues indefinitely till something occurs to check it. An intense external stimulus, producing vivid sensations and perceptions, may put an end to your thinking. You are aroused from thought by hearing some one call you, or by some striking object appearing before your eyes. If the central nerve impulses are discharged into a

motor pathway, and you start to act, the train of thought is broken off. The sudden thought that it is time to attend a class sets you in motion, and ends your reverie.

Several different kinds of thought trains may be distinguished: (1) *Casual thinking*, which is subject only to the general laws of association. This is the ordinary type, which we have been discussing. (2) *Dreaming*, in which the flow of thought is modified by a special condition of the brain called *sleep*. (3) *Hypnotic thought processes*, which are modified by a special condition of the nervous system called *hypnosis*. (4) *Rational thinking*, in which the succession is determined by a special mental attitude and by the meaning of the thoughts.

Dreams. — Sleep is a special condition of the nervous system. It is an essential part of the repair process of living creatures. The period of sleep enables the organism to restore the nervous energy used up by the activities of waking life. In man the period covers about one-third of the entire day. As a physiological condition, sleep is just as normal as waking life, but the mental activities that occur during sleep, called *dreams*, present many unusual features.

The distinctive fact in dream experiences is that the central neurons are almost wholly cut off from their sensory and motor connections. The synapses which join the sensory paths with the brain and the brain with the motor paths become highly resistant. Only intense impulses penetrate to the higher centers, or impulses which play a prominent part in our mental life.

During sleep we are not ordinarily affected by sounds, lights, odors, or other external stimuli. A loud sound may penetrate to the centers and arouse us; or a sound which possesses unusual personal interest, as when the child's fretting wakens the mother. Organic stimuli are often very effective; the unpleasant and terrifying dreams known as nightmares are attributable to indigestion. Temperature stimuli suggest

dreams of a conflagration or of walking the streets unclad. Tactile stimuli are rarely effective.[1]

On the other side of the arc, motor discharge is checked, so that an idea which in waking life would lead to speech, locomotion, or some other coördinated activity either remains without any motor expression, or at most produces a very slight effect. Occasionally a strong motor impulse breaks down the resistance, as when we turn over in bed or talk in our sleep. Sleep-walking occurs when specially strong motor impulses find effective expression without wakening the sleeper. The very beginning of such movements serves to waken most persons, but in certain individuals and under certain conditions *somnambulism* proceeds in a coördinated manner. The same is true of sleep-talking. Where the motor impulse does not produce actual movement, slight twitching movements of the feet, arms, fingers, and throat often occur. These incipient movements are probably more common than is generally supposed.

There is usually no indication to an outside observer that the sleeper is dreaming, and the sleeper himself may recall nothing on waking. This is not conclusive proof that the higher brain centers are inactive. The connection between sleeping thoughts and waking thoughts is often very slender; we sometimes recall a dream immediately after waking only to lose all recollection of it soon after. When any one tells us that he never dreams, it means only that he is unable to *recall* dreams. On the other hand, the fact that many dreams are forgotten does not justify the sweeping conclusion that the sleeper is always dreaming. It may be that sometimes the entire cortex is inactive.

Dream life differs from waking life principally in having a much narrower field. Because the cortical centers are largely cut off from sensory impulses, our experiences consist

[1] During sleep the autonomic processes proceed much as in waking life. The breathing is more regular and may take on a new rhythm.

chiefly of imagery and thoughts. This seems sufficient to explain the fantastic character of dreams and the absurdities they exhibit. Dream images may not be actually more intense than the imagery of waking life; but since there are no sensations with which to compare them, they stand out vividly and seem to be actual perceptions.

The strangeness of our dream experiences is due to this mistaking of our thoughts for perceptions. Any one of your dream pictures might readily have come to you as a *thought* in waking life, and it would not have seemed absurd. For example, it is entirely natural for you to think of your friends after their death. But you do not see your dead friends in waking life, so that their lifelike appearance in dreams is often startling — after you awake. At the time it seems quite natural, because your brain centers are cut off from one another, so that you do not associate the thought of the man's being dead with his appearing before you.

At times some incongruity may be noticed during the dream itself, and may puzzle us. I was once surprised in a dream to see a friend who had been dead for some years. At once I recollected that the report of his death was a mistake — that it was really another friend who died.[1] This supposed *memory* recollection was merely a new *thought;* in waking life it would be called an hypothesis. We would *suppose* the report of the man's death was a mistake.

The incongruities and absurdities in the *succession* of incidents in dreams are to be explained in the same way. A dream is really a train of thought and not a succession of perceptions.[2] But our dreams seem at the time to be real perceptions. After we awake many of the incidents strike us as

[1] This sometimes happens in waking life. Some time ago the papers falsely reported the death of C. R. W. Two weeks later I met him. Not having heard the report denied I was far more astounded than in the dream incident.

[2] The train of thought described on page 313 might easily have occurred as a dream; and we would have considered it a most fantastic dream.

absurd because real beings and things do not act in this fashion. The motion pictures have succeeded in reproducing in visible form many striking effects which formerly were obtained only in dreams and vivid imaginations. A study of cinematograph effects will help us to appreciate better the construction of dreams.

Since dreams are thoughts, and not voluntary acts, it is not surprising that honorable persons sometimes dream of committing dishonorable actions, such as lying, stealing, or killing. Every one thinks of these acts, though in waking life we usually think of them as performed by some one else. In dreams, experiences take a more personal form. When you dream of the act of stabbing, the muscle-sense memories are more vivid than in waking life, and the brain conditions of volition are reproduced without the motor activity; you picture *yourself* as performing the act. One need not be alarmed at such dreams. They do not imply any hidden flaw in a person's character. A *thought* is by no means always a *wish.*

Subconscious life plays a more important part in dreams than in waking experiences. Just as ideas are more vivid through the absence of 'real' perceptions, so subconscious experiences are apt to rise to the surface and become conscious during sleep, because there are fewer intense impulses in the brain to inhibit them. Our general attitudes also influence the direction of our dream experiences just as they direct our trains of thought in waking life.

To sum up, dream life differs from waking life in the following respects: (1) the higher brain centers are cut off from one another and from most sensory and motor paths; (2) as a consequence, our experiences are fragmentary and incoherent, and thought is mistaken for real perception; (3) our personal control is diminished, and our subconscious tendencies are more prominent. With the exception of these differences it appears that dream experiences are formed in the same way as waking thoughts, and that dreams (that is,

trains of thought in sleep) follow the same laws as ordinary trains of thought in waking life.

Hypnosis. — Another special condition of the nervous system is *hypnosis*.[1] In hypnosis the sensory and motor paths are not cut off from the brain as in sleep, but certain pathways become more resistant, while others are unusually open to connection with the centers.

There are various ways in which a person may be hypnotized: by having him fix his gaze on a bright object, or talking to him in a droning voice, or making him move his two hands in a rhythmic, circular way. He will then gradually pass into the hypnotic state and lose the power of coördinating his thoughts and controlling his actions.

The hypnotized person is peculiarly susceptible to suggestion. If told that he is in a lake he immediately begins to make swimming movements. If the hypnotizer tells him that a sheet of blank paper is a letter from a friend he starts to read it. His actions are not inhibited as in sleep, but they are controlled by the mind of another person. Generally the hypnotic subject is governed by suggestions from the one who induced the hypnotic state and he pays no attention to anyone else. The process of hypnotizing focuses his attention on one individual.

In normal life our personality, molded by past experiences, inhibits to a great extent the effect of suggestion. In the hypnotic state these inhibitions are lacking, and suggestions received from the hypnotizer are all-powerful. The hypnotic subject does what he is told to do. The ordinary sense of fitness is lacking and he will unhesitatingly perform acts which ordinarily would be checked by the feeling of absurdity or fear of ridicule. Suggestions are resisted only if they conflict with his deepest moral sense.

Hypnotic suggestion may induce anesthesia of one or more

[1] This is popularly called *hypnotism*. Hypnotism means the 'theory of hypnosis'; *hypnosis* is the physiological condition.

of the senses. The subject will not flinch when pricked by a needle or touched with a hot iron, if the proper command is given. At other times the hypnotic suggestion may bring about hyperesthesia; the subject is able to distinguish one blank sheet from another when told that they are photographs of different people. Hypnosis is a condition in which the thought-life is raised to the focus; perceptions and other experiences are subordinated to them. The stream of experiences in hypnosis follows the laws of thinking rather than the laws of perception; but the succession of thoughts is constantly guided by verbal stimuli; it is not self-guiding, as in ordinary thinking and in dreaming.

The peculiar behavior of a hypnotized subject is understood if we compare him with a dreamer. In both sleep and hypnosis our thoughts are especially vivid and are mistaken for perceptions. In sleep the flow of thoughts is ordinarily not disturbed by outside impressions nor accompanied by motor activity; in hypnosis the succession of thoughts is determined by verbal suggestions from another person and results in motor activity appropriate to the thought, but not in keeping with the real surroundings.

Summing up, (1) in hypnosis there is an abnormal condition of the brain centers; (2) the hypnotic subject receives external stimuli, but only verbal suggestions have conscious effect; (3) he is able to make real movements instead of having merely ideas of movement and speech as in sleep; (4) his senses may be sharpened or blunted by suggestions; (5) his actions are more completely controlled by suggestion, and the effects of this suggestion may last over into waking life. For practical purposes we may consider hypnotic experience as a dream-like mental condition, induced and controlled by some one else, instead of by the dreamer's own mental processes.

Reasoning. — Rational thinking, or *reasoning*, is another special kind of thinking. Dreams and hypnosis are lower and

less organized than casual thinking, while reasoning is a higher, more adaptive variety. The stream of rational thoughts is made up of concepts and judgments; the succession is determined by their meaning instead of by mere similarity and contiguity, as in casual thinking.

In our waking life the stimuli from the external world affect us in haphazard order, so that the succession of perceptions is often quite unsystematic. This haphazard connection of unrelated perceptions tends to be reproduced in our ordinary trains of thought, so that we often associate objects or events which are not actually connected in nature. You may readily think of gold being discovered in your own back yard, and go on to picture how you would mine it and what you would do with the proceeds. This train of thought is casual thinking. Very different were the thoughts of Captain Sutter in 1848 when gold was actually found at his mill. His thinking was about real gold and the real consequences this discovery would have on his life.

Reasoning is a special type of thinking in which the associations *correspond to processes in nature.* If the original thought in the series corresponds to real things or events or facts, then the whole train will represent something real. If we think of fourteen dollars added to a pile of twenty-seven dollars we conclude that there will be forty-one dollars in the pile. This is rational thinking, because whenever we actually carry it out the result tallies with our thought. Of course we may not have the fourteen dollars to begin with; and then the result does not happen at all. But the thinking is rational just the same: if we lack the dollars we can try it with pennies or pebbles or eggs or pages in a book or anything else. The conclusions which we reach through reasoning are called *inferences.* An inference is a new thought, based on associated meanings or values, which we believe will tally with reality.

How has man gained the ability to reason — to think rationally? Reasoning is not a special mental power. It is

an outgrowth of ordinary thinking, due to two circumstances: (1) The uniformity of nature. We learn that $14+27=41$ because we always obtain that result — with dollars and eggs and everything else. Nature is built in this way. Everywhere and in every phase we know of, the workings of nature are found to be the same. (2) The complex organization of the human brain. Our language centers enable us to devise arbitrary words, "fourteen," "twenty-seven," etc., which are symbols instead of pictures. By means of these symbols we can do *abstract* thinking — we can connect fourteen and twenty-seven in thought, even without concrete things to work with. When we find that the abstract relation actually holds for dollars and eggs we tend to apply it to other things; but it is the language centers that enable us to get the abstract ideas in the first place.

There are many other varieties of reasoning besides arithmetic. Logic is one of them. Man has discovered that if A is greater than B, and B is greater than C, then A is greater than C. If John is older than Henry, and Henry is older than William, then John is older than William. These and other logical relations are used in reasoning.

Rational thinking is applied also to special situations. When you think of Niagara casually, your flow of thought may follow all sorts of directions. You may think of your chum's trip to Niagara and Buffalo; that you would like to hunt buffalo in the plains; that a carpenter's plane would smooth a man's face quicker than a safety razor; and this may remind you of meeting a fellow named Gillette. None of these steps of thought is based on meaning; they depend merely on chance similarity of sound or chance contiguity. They lead you nowhere. But if you think of actually going to Niagara, your train of thought tends to become rational: you think of how to reach the place, of getting a time-table, drawing money, packing, getting to the station, etc. The initial thought in this case is not the *word* Niagara, but the

concept Niagara, or a *judgment* about going to Niagara. The science of logic points out the proper use of reasoning. A course in practical logic is invaluable in training us to reason correctly.

Rational thinking sometimes fails. My adding machine gets correct results in summing up a column of figures oftener than I do. People have been known to miss their train even when the trip was carefully planned out beforehand. These failures are due to a variety of causes. The most common cause is a faulty connection in the brain. The rational association $4+7=11$ becomes very strong through repeated experience, but now and then the casual association $4+7=12$ may creep in when we add up a column. This is called a fallacy. Slips in reasoning are common in every one's life, but a careful thinker is likely to discover the error by noting some inconsistency in the results.

Sometimes the failure is due to our expecting too great uniformity in nature. Encke's comet did not return quite as soon as the calculations predicted: something not foreseen by astronomers delayed it on the way. Your trip to the Falls may be frustrated by a new time-table or a railroad accident. In such cases there is no fallacy in your inference; there is merely ignorance of some important factor in the situation.

A *superstition* is imagining some relation in nature which does not really exist. The ancients reasoned that a certain plant must be a remedy for heart trouble, because its leaves are heart-shaped. If you pronounce some mystical word, the winds or the mountains will obey your commands, because human beings obey you when you speak with authority. Thirteen at the table must mean death to one of the company, because there were thirteen at the Last Supper. Once these fanciful connections are formed in our minds they are hard to eradicate, — especially if testing their falsity might mean death to the experimenter. Yet the only way to dis-

tinguish between a correct inference and a superstition is for some one to try it out and see what happens.

There is another, more insidious misuse of reasoning. Often we arrive at a decision by some train of casual thinking and then try to make our decision look rational by constructing a plausible explanation. You advocate opening a new street, or laying a sidewalk, or putting in more lights, on the ground of great public need; but you originally thought of the improvement only as a benefit to yourself personally. You are perfectly sure it is the scenery that decides you to take that stroll — not the girl you are likely to meet on the way. The salesman knows a hundred reasons why his goods are better than any others; and he honestly believes them. This mental process of constructing artificial reasons is called *rationalization*. If you analyze your real motives you will be surprised to find how frequently the rationalizing process occurs, and how strong is the temptation to use it. The teacher of practical ethics might well begin his instruction with the injunction: "Be honest with yourself."

Reasoning is the most important step in the growth of adaptive behavior. It enables us to anticipate events and prepare for them beforehand. Rational thinking is most effective when it is supplemented by casual thinking. We picture imaginary situations and consider how we would act or how nature would act. When we work with scientific hypotheses we combine the two types of thinking.

The General Stream of Experiences. — Our conscious life is a vast stream comprising experiences of many sorts. With the exception of perceptions and thoughts we rarely have a long uninterrupted succession of any one kind of experience. A feeling usually brings about action, which transforms the feeling into an emotion. An emotion is apt to exhaust itself quickly and pass over into thought or volition or speech. Volition results in movements which usually change our situation and bring about new perceptions. In the general vista

of experience there may be long unbroken stretches of perceptions and long unbroken stretches of thought; between these, small patches of other experiences are interspersed.

In almost every human being, whether civilized or savage, perceptions are most frequent and form the core of mental life. Among educated adults of civilized communities thought and imagery occupy a good second place, while among primitive peoples the emotional life is more important than thought and imagery. Motor experiences — volition and language — generally rank ahead of the emotions among civilized races.

Our mental life at any instant may include more than one experience: a perception, a thought, and a volition may all be present together, one of them being vivid, the rest marginal or subconscious. Their relations change; the perception may fade into the background, and the thought which was indistinct may advance to the foreground. When you are out walking with a friend your attention oscillates between the perception of things about you and the thoughts and utterances of your conversation. In reality both perception and thought are present all the time; the change is in the focus of attention — in the relative vividness of the two.

What kind of experience will occupy the focus of attention at any given moment is determined by the relative strength of the various nerve impulses occurring in the brain at that moment. This depends partly on the intensity of stimulation. A loud noise, a flash of light, a sharp blow, or a muscular strain may force a perception upon us and crowd all other experiences out of the focus. But unless the new stimulus is very intense it finds a rival in the nerve impulses that are already active in the brain. The new sensory nerve impulse may be wholly or partly inhibited by the existing central impulses, or it may combine with them. The direction of our interest and attention is important in determining what the effect will be. If you are interested in following a trail in the

woods, the most trivial signs will strike your attention — a blazed tree, a broken twig, or a footprint; for the time being, the perceptive life dominates. A geometrician like Archimedes, on the other hand, may be so absorbed in reasoning out a problem that no external stimulus will move him. An emotional man flies into a violent rage or into wild exultation over some event that arouses merely perception or thought in another.

In short, the succession of our experiences in the general stream of mental life depends both on stimulation and on the make-up, training, and present condition of our nervous system. It follows in part the laws of the stream of perceptions, and in part the laws of the stream of thought. Our present, persistent personality, which has been built up out of all our past experiences, is an all-important factor in determining the course of the stream.

The Stream of Actions. — Mental life includes not merely our experiences but our actions. These also form a series. Every act involving muscular contraction stimulates the muscle sense and may lead to another act or to a continuation of the same activity. We are seldom entirely quiescent. When we are not actually contracting some muscles, we are usually maintaining their tension. Try at the present moment to relax your facial muscles, or your legs, or your arms completely. You will find that there is some muscular tension in these members, though you may have supposed they were quite relaxed.

Even simple acts, like catching a ball, involve a series of coördinated movements lasting an appreciable time. And when the act is completed it generally brings about a new situation which demands another response. When the fielder has caught the ball, he has to throw it; or if his play ends the innings he is no longer wanted in the field and is expected to run in. When the game is over he has to dress, go home and prepare for dinner, or study, or see a friend.

Rarely, except during sleep, is the response life resting. Waking life is a flow of actions — a continuous succession of responses, one after the other, each determined by our successive experiences.

Summary. — The experiences and responses which have been examined in the foregoing chapters are not detached events. They form a continuous stream or succession. The flow of experiences depends partly on what effects us from outside, and partly on our inherited and acquired mental conditions. In the case of *perceptions*, the external stimuli are largely responsible for the course of experience; in *thought*, the succession is determined by the mental principles of association.

Besides the ordinary or *casual* trains of thought, thinking has two somewhat abnormal varieties called *dreaming* and *hypnotic experiences*, which occur in sleep and hypnosis, respectively.

A higher form of thinking occurs when the association is based on the meanings and values of our thoughts. This is called *reasoning*. The materials used in reasoning are concepts and judgments; the inferences which we draw from them tend to correspond to real events or general truths of nature.

Our receptive life is a succession of perceptions, thoughts, reasoning, dreams, emotions, volitions, and other experiences, which come and go, wax and wane, continually. Our active life is a succession of responses.

PRACTICAL EXERCISES:

69. Test a person's association time with a stop-watch. Choose some noun or verb and say it distinctly, at the same time starting the watch. Instruct the subject to call out the first word which he associates with your stimulus word, then the first word associated with this second word, and so on till he has made (and uttered) 10 associations. Stop the watch and note the time. Repeat several times and find his average association time for a single association.

70. Sit with pencil and paper and note the first word you see in a book opened at random. Write down the first idea which it suggests, then

the first idea suggested by this latter, and so on for a series of 15 or 20 successive associations. Examine each association and determine which of the laws of association are responsible for its formation.

71. Chain reaction. Let a group of persons, including the experimenter, join hands in a circle. The experimenter holds a stop-watch. Without warning he presses the next person's hand, starting the stop-watch with the same movement. The instant the second person feels the pressure he presses the hand of the third; and so on, around the circle. When the last person presses the experimenter's hand, the experimenter stops the watch. The average reaction is found by dividing the total time by the number of persons in the circle, since each has reacted once.
72. Analyze the succession of experiences in one of your dreams. Report what laws of association operate; explain if possible the incongruities.
73. Attend carefully to a conversation between two persons. Note which associations are 'rational' and which are 'casual.'
74. Examine the succession of your experiences during the past 10 minutes and study the relation between perceptions and thoughts in the series.

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CHAPTER XV

HUMAN CHARACTER

Permanent Mental Conditions. — Experiences leave traces in the structure of the nervous system. These retention traces are revived in the form of memories or imaginations, and they tinge our perceptions with a 'sense of familiarity.'

Besides this, retention has another and far more important effect on mental life. When the same sort of experience is repeated over and over again, the trace may deepen into a more or less permanent *set* of the nerve substance. These enduring traces affect our way of receiving stimuli, and lead to stereotyped behavior. The pathfinder watches for signs of the trail in the forest; the experienced football player finds the gaps in the opposing line; the pessimist always sees the dark side of things. Each one, by repetition of the same sort of experience, has acquired a *mental attitude* toward certain features of the environment. As time goes on, these attitudes tend to become more stereotyped and to cover a wider territory. Each trade has its own vocabulary and code. One can often guess rather accurately a man's occupation by the sort of words and phrases he applies to ordinary situations. The sailor tells you about the house on the *starboard* side of the road; the chauffeur, acting as butler, *parks* the dishes on the serving table.

A great quantity of attitudes are built up out of material furnished by the external senses. These fixed ways of perceiving and thinking are called *cognitive attitudes.* The sum-total of our cognitive attitudes make up our intellectual character, or *intellect.* In the same way all the attitudes based on a person's systemic life combine to form his affective character, or *temperament;* his motor attitudes, taken together,

make up his motor character or *skill;* a man's social attitudes determine his moral character or *morality.* *Character* is a more permanent and fundamental condition than the attitude. It is made up of a vast number of attitudes.

The several phases of an individual's character are not independent. They interact upon one another. Your temperament may be modified by your moral character, or by your intellect. Your mental nature is the sum-total of all the permanent mental conditions that have developed within you up to the present. This all-embracing result of mental organization is called *personality.* Personality includes our innate tendencies, our attitudes, and our character.

Attitudes, character, and personality are not particular experiences, but *permanent mental conditions* which underlie experiences. Attitudes change very gradually. They are molded slowly; once formed they alter only as the trend of experience takes another direction. The city-bred man takes a citified attitude toward the world; it is only after long experience with country life that he can change this attitude and see the world with the countryman's eye. The countryman is bewildered and helpless on his first visit to the city.

Character alters far more slowly than attitudes. Personality undergoes a still more gradual development and transformation. The growth of a man's personality covers the entire period of his lifetime.

Attitude

Nature and Classes of Attitudes. — A mental attitude is a permanent *set* of our mental and nervous system which modifies the effect of stimuli and determines how we shall respond. Your chum lands a fine job. How do you take the news? Are you 'tickled to death,' or do you envy him the good luck which has not come to you? The news is the same in either case; your attitude *and your behavior* are different.

Because attitudes are not particular experiences we cannot examine them like perceptions and emotions. They may be studied through the motor expressions which they bring about. An alert attitude, a sullen attitude, a credulous attitude, almost inevitably lead to different kinds of behavior. The popular meaning of the word *attitude* emphasizes this. It means a 'motor posture.' In psychology attitude means this and more; it includes the *mental condition* which governs the motor posture.

Every attitude is the product of repeated experiences. If you live in a certain environment you are likely to develop certain attitudes which belong to that environment. The street urchin acquires a whole raft of attitudes from his surroundings which the farmer's lad could never develop. City life develops alertness; country life promotes observation of nature. Our attitudes are sieves through which certain experiences are strained out and others are concentrated. Attitudes begin to develop early in life. Fear of the dark or of thunder can usually be traced to some experience in childhood. It may take years to eradicate certain impressions made by the tales of an ignorant nurse. You were told of the man who was tossed so high that he stayed up in the air, floating about forever; the notion sticks by you long after you are familiar with the principle of gravitation.

Attitudes are classed according to the sort of experience that develops them. The attitude which grows up in connection with perceptions and ideas is called *interest*. Our feeling experiences develop a type of attitude called *desire*, and our simple motor experiences develop the attitude of *attention*.[1] These three primary attitudes dominate our mental life and exert a powerful influence on every particular experience of the corresponding type.

[1] Notice the two different uses of the word *attention;* (1) it denotes the mental process of focusing an impression and making it more vivid (ch. vi); (2) it also means the motor type of attitude.

In popular language we say that feelings cause desire, that the things which we perceive arouse interest. The truth is that the desire attitude and the interest attitude are the product of a life-time; they are our way of receiving incoming stimuli. Interest is not something in the mind which is aroused by what we see; it is a mental bias or set which causes certain perceptions or ideas to be especially vivid and persistent. Attention is not really something that we *turn* toward an experience, but it is a mental tendency to adjust our muscles this way or that according to the situation.

The attitudes that grow out of emotion, thought, and other secondary experiences develop differently from interest, desire, and attention. Instead of becoming uniform they take on many different forms. The emotional attitudes are especially rich in their shading. It is not difficult to distinguish between a friendly, an affable, a gracious, and a devoted attitude; if you train yourself to study human nature you will be able to distinguish between the domineering, pompous, arrogant, overbearing, lordly, condescending, and superior attitudes which men in authority almost inevitably assume. Language attitudes are few in number and are not especially significant. Attitudes of thought and moral attitudes are more numerous. All these secondary attitudes give diversity to human character. [Table XIV.]

TABLE XIV.— HUMAN ATTITUDES

Attitude	*Mental Basis*
Primary:	
Interest	Perception, Ideation
Desire	Feeling
Attention	Conation
Secondary:	
Dispositions	Emotion, Sentiment
Appreciation	Thought
Conscience	Social situation
Proclivities	Volition
Language attitudes	Language
Ideal attitudes	Ideals

Interest, Desire, and Attention. — The three primary attitudes — interest, desire, and attention — generally work together; their influence is observed in almost every experience. Suppose you are watching a baseball game. The chances are that you are there on account of your *interest* in the game. As you watch the significant plays you look at the actions of the players with interest — with a very different attitude from your cursory perception of the foul-line or the glove accidentally dropped on the turf. If you are interested in one of the teams, you have a *desire* that this team shall win. At critical points in the game this desire becomes strong and causes violent heart-beating, deep breathing, and perhaps a feeling of 'goneness' in the pit of your stomach. You *attend* to each play through slight motor reactions. You knit your brows, clench your fists, fix your eyes; all these are attention attitudes.

These three attitudes are so closely connected together that it is not easy to distinguish them. In popular language they are often confused. We speak of attention when we really mean interest. This confusion may be avoided if we practice careful observation of our own experiences. Attention is our motor attitude, interest is our attitude toward the perception or idea, making it more vivid and prominent.

Attention shows itself in muscular adjustment or tension, which enables us to receive impressions better. When you follow a moving object with the eye, the eye movement is the expression of your attention attitude. It is not the significant response to the stimulus, but it helps you to perceive the object better, and in this way you are able to respond more suitably when the time comes. Your interest in the moving object is the attitude that makes this object 'stand out prominent in consciousness.' Moving objects, flashing signs, loud noises, and other intense stimuli are likely to arouse attention, even though they lie outside our usual line of interest. This is called *involuntary attention* and it

usually carries with it *involuntary interest.* A prosy speaker pounds on the desk and makes his hearers sit up and take notice; so far as his subject-matter goes they would prefer to relax and enjoy a nap.

In general, a person's interest follows certain definite lines; it brings out the things he is most accustomed to observe and the ideas he is most accustomed to think. In reading the morning paper one man spends most time on the stock quotations, another on the sporting page, a third man on murders and accidents, a fourth on the foreign news and editorials. The line of your general interest makes some particular part of the paper loom large in your mind and fixes your attention.

Desire differs from interest and attention in having two opposite forms, corresponding to the two feelings of appetite and aversion. Our attitude toward pleasant experiences is called *satisfaction.* If we are experiencing something unpleasant and imagine some pleasant alternative, our attitude is dissatisfaction and something more: it carries with it a picture of removing the unpleasantness or transforming it into pleasantness. This attitude is called *want*, or need.

Satisfaction is less distinctive than want. In satisfactory situations the pleasantness of the experience itself dominates, and the attitude usually plays an unimportant part. But in unpleasant situations the attitude of 'want' tends to share the focus with the feeling of unpleasantness.

In discussing memory we found that definite systemic memories and systemic ideas rarely occur. Instead of remembering this feeling or that, we generally have a *want,* which is an attitude due to many past feelings. You want a motor car because of imagined pleasure. You want breakfast not merely on account of present hunger, but because you recall the satisfaction of eating breakfast on other occasions. The desire for honors, wealth, praise, success, rests on similar grounds. Want leads to motor activity which tends to remove the unpleasantness or to bring about the desired

pleasantness. Our actions do not always succeed in accomplishing this. But it is characteristic of the want attitude that it spurs us to action. As our mental adjustment becomes perfected, we become better able to do the right thing, which in this case is to fulfill the desire. When this is accomplished the want gives way to satisfaction.

Interest, desire, and attention enable us to guide and control the course of our experiences and actions. In this respect they belong among the *motives* of human life.

Emotional Attitudes. — No phase of human life is more worthy of study than our emotional attitudes, or *dispositions*. To one who has learned to interpret them, they furnish one of the very best indications of a man's personality. In civilized society, emotional expression is usually repressed; only critical situations call forth unbridled displays of emotion. But the emotional *attitude* is rarely washed out completely. The emotion of joy simmers down into a *cheerful* disposition; repressed emotions of anger lead to a *hostile* disposition. In talking with a person you can usually tell whether he is annoyed or pleased, whether he is well-disposed toward you or defers to you or considers himself a bit above you, by something in his manner or tone, if not by his words and actions. You know at once if a stranger is distrustful or ready to accept you. You can often tell that a certain man is worried or overburdened before he says a word.

Our most casual acts and words may be thoroughly saturated with concentrated emotion. "They left me out." "In my humble opinion —." "Won't you listen to me?" Who cannot guess the emotional background of these phrases! The poker player trains himself to suppress or disguise even the simplest manifestations of feeling, and the business man endeavors to obliterate them with more or less success. Often it becomes a contest between concealment and detection — not unlike the struggle for supremacy between defensive armor and penetrative shells. If you cannot get rid of

your own emotional display, you can at least learn to detect the slight twitchings of certain muscles and inflections of the voice in other persons, which will reveal to you their emotional dispositions.

Popular psychology distinguishes between a *disposition*, which is a more or less permanent attitude, and a *mood*, which is liable to frequent fluctuation. The distinction seems valid, but it is of social rather than psychological importance. Our emotional attitudes become established by slow degrees, and the border line between a passing mood and a permanent disposition is indefinite.

Sentimental attitudes are closely related to emotional attitudes; this probably accounts for the popular confusion between emotions and sentiments. Doubt gives rise to a *perplexed* attitude; strong belief mingled with strong disbelief produces a *biased* or *prejudiced* disposition. Certain dispositions are derived directly from instinctive tendencies, with no emotional tinge whatever; as for instance the *miserly* and *orderly* dispositions.

Nearly every class of emotion develops a corresponding attitude or disposition.[1] In Table XV only the most noticeable dispositions are given; it would be hopeless to include the numerous finer shades. The great wealth of emotional attitudes is in striking contrast with the one single form of the *interest* attitude.

Even our judgments of fact are usually tinged with emotional bias. Read any account of the American Civil War written in the '60's or '70's — or even the '80's. Notice the adjectives applied to Lee and Davis by Northern historians, or to Lincoln, Grant, and Sherman if the writer is a Southerner. It fairly startles us to find our own countrymen manifesting these emotional attitudes in writing plain history. The school histories of an earlier generation took a similar emotional attitude toward the 'Tories' and 'red-coats'

[1] Compare Table XV with Table VIII (p. 215).

TABLE XV.—HUMAN DISPOSITIONS

1. *Expressive*		2. *Reproductive*	
Attitude	*Emotion*	*Attitude*	*Emotion*
Cheerful	Joy	Affectionate	Love
Despondent	Grief	Lascivious	Lust
Dazed	Shock	Jealous	Jealousy
Frivolous	Mirth	Motherly	Tenderness
Zealous	Ecstasy		
Erratic	Restiveness		
Romantic	Exuberance		
Devout	Wonder		
3. *Defensive*		4. *Aggressive*	
Attitude	*Emotion*	*Attitude*	*Emotion*
Cowardly	Fear	Hostile	Anger
Courageous	"	Vindictive	Hatred
Aversion	Disgust	Malicious	Envy
Cautious	Timidity	Ambitious	Pride
Reserved	Shame	Arrogant	"
Servile	Awe	Bold	Exultation
5. *Social*		6. *Instinctive and Sentimental*	
Attitude	*Emotion*	*Attitude*	*Basis*
Devoted	Affection	Miserly (Avaricious)	Acquiring instinct
Friendly	Cordiality	Orderly	Cleanliness
Compassionate	Pity	Nomadic	Wandering instinct
Attachment / Loyal	Gratitude / Admiration		
Antagonistic	Detestation	Credulous	Belief
Sullen	Revenge	Skeptical	Disbelief
Distrustful	Suspicion	Perplexed	Doubt
Supercilious	Scorn	Biased	Belief and Disbelief

in the American Revolution, and those of the next generation will emotionalize toward the several nations concerned in the World War. The killing of the Austrian archduke has been described both as a dastardly assassination and as a sublime act of patriotism. The judges who sentenced King Charles are still called 'regicides' by sturdy British royalists — a suggestion of the word homicide, with its moral stigma. Where the narrative itself is unimpeachable the choice of adjectives will frequently betray to an acute observer the writer's emotional bias.

Most of our dispositions, like our emotions, are imper-

fectly adjusted to the conditions of civilized life. If we test our attitudes (or better still the attitudes of others) by social experience, we find that the emotional element generally hampers the intercourse of man with man. The servile disposition is as disconcerting as the arrogant. There are some exceptions. Loyalty, compassion, and the like are dispositions which promote coöperation among men and assist the socializing trend of human development. From the pedagogic standpoint the early training of emotions and dispositions seems even more important than the cultivation of motor habits.

Appreciation and Conscience. — Of the remaining attitudes the most important are those which develop out of thought experiences and social situations. The principal attitudes in these two spheres of life are shown in Table XVI, together with certain prominent attitudes of other sorts.

A special group of attitudes develop in connection with our casual, ordinary thinking. Some persons constantly revert to the past; they live in *retrospection*. Others reach out toward the future; they tend to take the *anticipatory* attitude. The highly imaginative mind assumes an *imaginative* attitude; or this tendency may result in *desultory* thinking.

The attitudes which grow out of rational thinking may be grouped together under the head of *appreciation*. One of the most important of these is the problem attitude.[1] This means that when we are given a problem or a question to solve we tend to keep this problem before us as the basis of our thinking. A succession of thoughts follow, but they *all relate to this particular problem.* The attitude is not the particular problem, but the *tendency* to keep a definite problem before us and direct our thoughts with reference to it. In the case of Langley or the Wright brothers, the problem *thought* was how to devise a flying-machine; the problem

[1] Also called *task* or *question* attitude; the German equivalent *Aufgabe* is frequently used in English books.

TABLE XVI.— HIGHER HUMAN ATTITUDES

1. Thought Attitudes

Attitude	*Basis*
(a) *General:*	
Retrospective	Memory coefficient vivid
Anticipatory	Purpose (volition marginal)
Desultory, Imaginative	Associative thought
Naïve	" "
(b) *Rational Appreciation:*	
Interrogative (Problem attitude)	Doubt (feeling marginal)
Impartial, Dogmatic	Belief (" ")
Interpretive	Meaning
Evaluative	Value
Esthetic appreciation	Esthetic sentiment (feeling marginal)
Logical appreciation	Rational thought
Analytic	" "
Synthetic, Constructive	" "
Critical	" "

2. *Social and Moral Attitudes (Conscience)*	3. *Other Secondary Attitudes*
Conciliatory, Coöperative	(a) *Volitional Attitudes (Proclivities):*
Contrary, Competitive	Persevering, Obstinate
Inculpatory, Condemning	Vacillating
Laudatory, Approving	
Judicial	(b) *Language Attitudes:*
	Receptive
Self-centered, Self-satisfied	Expressive
Altruistic	Voluble
Penitent	Reticent
Suppliant	
Forgiving	(c) *Ideal Attitudes:*
Prudish	Idealistic
Irresponsible	Practical
Superstitious (fetish and tabu)	Sensual
Duty-bound (moral obligation)	Scientific
	Artistic

attitude enabled them to maintain this central thought persistently year after year, or to return to it repeatedly, so that their thinking was ever on the subject of human flight.

The *interpretive* and *evaluative* attitudes permeate our perceptual life as well as our thoughts. We become trained to observe differences in kind and quantitative differences among the objects that we perceive. An interpretive atti-

tude toward thought is cultivated by modern education. Writers learn to appreciate subtle distinctions in the meaning of words. Even the average reader acquires an attitude toward individual words. James speaks of the feeling that attaches to such minor words as *and*, *if*, *but*, and *by*. These are really instances of the appreciative attitude, which leads us to interpret or evaluate the relations of words in a sentence with as much keenness as we interpret scientific laws.

Esthetic appreciation is the attitude which approves a musical composition or a painting as artistically correct, or condemns it on account of faulty technique. *Logical appreciation* is our thirst for logical accuracy and correct reasoning, whether we agree with the premises or not.

In our relations to other men and to society at large a number of important *social attitudes* have arisen. A satisfactory classification of these is difficult, because they shade from emotional or volitional experiences into the sphere of conduct by gradual degrees. Thus the *fault-finding* attitude contains a large element of emotion, but is tinged with a slight sense of obligation toward society; the *inculpatory* attitude of a public prosecutor, on the other hand, has scarcely any emotional tinge. Midway between these is the *accusatory* attitude so frequently noticed in modern political and community life.

The term *conscience* is commonly applied to moral and social attitudes. It generally carries an emotional tinge; and this is historically justified, because the emotions have been a powerful factor in developing our social ideals and conduct. But the notion of conscience may be extended to such unemotional phenomena as the *judicial* attitude and the sense of moral obligation (the *duty-bound* attitude).

The two attitudes of *contrariness* and *condemnation* illustrate the tendency of social and moral attitudes to become fixed and generalized. The contrary-minded man raises objections to anything his friends suggest. If you propose a

walk he wants to stay at home. If you order coffee, he orders tea. If you suggest going to one theater he prefers another. Any statement you make he is ready to challenge. The fault-finder takes a somewhat similar attitude in the moral sphere. He is forever picking flaws in the actions of others or in the social order of the community. "Why did n't you —," and, "Will you never learn —," and, "Any idiot would have known better," are typical of the condemning attitude. This same attitude revels in denunciation of the flaws in our social organization. When the fault-finder sees a break in the pavement the road commission is blamed. If he sees newspapers scattered about the public parks he berates our lack of social breeding.

Social and moral attitudes evolve in much the same way in all races, but the situations which evoke them vary greatly in different communities and stages of civilization. To put it the other way round, the same act or the same objective situation may yield very different attitudes in various races and culture-stages. It depends upon the traditions and customs of the people whether the attitude of obligation is assumed in a given situation or not.

For example, in many communities the child is regarded as the slave of his parents, who do not recognize any obligation toward their offspring except to feed and clothe them. In other communities there is recognized an obligation on the part of the parents to educate their children and fit them for their life-work.

Among the ancient Romans it was customary to expose deformed and weak children and let them die. A similar custom prevails to-day among the Eskimos. In other societies, such as our own, these weaklings are especially cared for and protected.

The *prudish* attitude illustrates even more strikingly how social attitudes depend on custom. In certain countries the sight of a woman's unveiled face shocks the moral sense.

Elsewhere the same shock is caused by a skirt revealing the ankle or the knee.

Even the attitude toward fundamental social relations, such as marriage, varies. From the standpoint of ethics the question of monogamy and polygamy is of prime importance. The science of ethics seeks to determine which of these two conceptions of *duty* is higher and better. Psychology studies duty only as a mental attitude — it does not attempt to pass judgment on its particular applications.

The attitudes which grow up in connection with volition, language, and ideals are not especially prominent. Volition develops the *persevering* attitude, with its extreme limit, *obstinacy;* in the other direction it may lead to *vacillation.* The use of language results in *receptive* and *expressive* attitudes; the *reticent* man is inclined to listen, while the *voluble* man insists that every one else shall listen to him.

An ideal is made up of thoughts, feelings, and volitions. Because of this complexity our ideals are seldom definite, concrete experiences. But they develop in the form of deep-lying *ideal attitudes*, which serve as motives of action and control the course of our lives. The idealistic man, the practical man, the scientist, and other types are distinguished on the basis of certain underlying attitudes which govern their behavior and conduct.

Attitudes and Consciousness. — Our attitudes always contribute something to our experiences. But usually the material they contribute is so obscure that it is not observed by the man himself at the time; it is subconscious. In an earlier chapter [1] we distinguished between *subliminal* and *subordinate* consciousness. Attitudes are generally subliminal — they are too faint to be noticed, though they exert a real and usually a powerful influence on our experiences.

But the question arises, what becomes of an attitude when it is not actually in use? Does it act subconsciously (that

[1] Ch. vi, pp. 136–138.

is, in a *subordinate* consciousness) when it is not working consciously? It seems probable that our attitudes do work subconsciously at times, but not often. An attitude is a retention trace, only it is cut far deeper than any single memory impression. Memories are not stored away in the mind; — the traces are there ready for use, but they are inactive so long as they are not actually used. And just so with our attitudes. Usually they are not active; they are neither subliminal nor are they constantly working in a subordinate consciousness. In fact all that persists between-times is the trace which makes the attitude possible. When the trace is aroused, then the attitude appears as an element in our conscious experience.

CHARACTER

Nature of Character. — Character arises from the consolidation of attitudes into more permanent trends of life. Just as the constant repetition of similar experiences leads to the development of fixed tendencies called attitudes, so our attitudes tend to combine into deep-lying general tendencies. A man's various thought attitudes are not independent, because man is an 'integrated' individual, leading one single life. If your interest centers in the study of biology, this affects your attitude toward languages; you are interested in the classics because biological terms are derived from Greek and Latin roots, or in German on account of the biological works written in that language. You may be wholly uninterested in Arabic or Russian, because they have only a slight bearing on your subject. On the other hand if you are a linguist you are interested to some degree in all languages, while your interest in biology may be limited to its use of Greek and Latin roots.

The interworking of countless attitudes in each sphere of mental life results in building up a 'composite attitude' in that sphere. Our thought and perception attitudes unite to

form a composite attitude toward this kind of mental material. This composite attitude is called our *intellectual character*. There are four principal lines of character development; three correspond to the three great varieties of sensation — external, systemic, and motor — the fourth arises from our social relations. These phases of character are:

Intellect (or intellectuality)
Temperament
Skill (or skillfulness)
Morality

The study of character carries us beyond the examination of separate experiences. We begin to see the individual as a whole, and we can compare one man with another. A man's character is his *general rating* in one of the four chief phases of mental life. It is the measure of his mental capacity and attainment in that phase of life.

Character is a combination of many particular attitudes. Each separate attitude may be regarded as a *trait* of character; and in practice our measure of a man's character consists in rating each important trait. Each attitude or trait manifests itself in concrete actions, so that practically we rate a man's traits and his character through his responses. College examinations are a means for rating a student's intellectual character in certain definite lines. A soldier's behavior in battle enables us to rate him for courage. Strictly speaking, a man's character is not the rating which his fellows actually give him;[1] for such ratings are liable to error. Character is really the rating which the man would receive if one could appraise him correctly.

Intellect. — Intellect is the phase of character which grows up in connection with the information received through our external senses. The impressions obtained through these senses are especially apt to be retained, so that our memories and thoughts of the external world play an important part

[1] This practical rating is a man's *reputation*.

in our lives. In rating a man's intellect, his ability to reason, think, and remember counts more than accurate perception and vivid imagination.

Intellectual development proceeds in two distinct directions, which correspond in a figurative way to *breadth* and *height*. The breadth of a man's intellect is measured by the *number* of different traits that he has developed; height means the *amount* of his growth in each independent attainment. The breadth of your intellect depends essentially upon the complexity of your inherited nerve structure, while its height depends more largely upon your education.

Both breadth and height must be taken into account in rating a man's intellect. There are instances of mathematical prodigies and memory geniuses who in other respects are far below the average mental level. And there are men of great mental versatility who fail to measure up to the average in any one particular; their minds are too spread-out. A man of high-grade intellect is one whose attainments are both broad and high.

Various attempts have been made to measure intellectual attainment. The great difficulty has been to distinguish the independent phases of intellect and to estimate their relative importance. An important step in this direction is the scale devised by Binet and Simon for measuring the mental growth of children. This scale consists of a large number of tests involving various mental processes, and so graded that the child's success in performing the tests will indicate his general intellectual level. For example, the growth of memory is tested by his ability to repeat sentences of various lengths and series of numbers of three, four, five, and more figures. Rational thought is tested by giving the child a statement which contains some absurdity, and asking him to point out what is wrong in it. There are also tests involving simple mathematical problems, tests of practical judgment,[1] tests to

[1] E.g., "What is the thing for you to do if a playmate hits you without

show the extent of the child's vocabulary, and many others. In practice the tests are arranged in order of increasing difficulty. Five tests cover each year of mental growth.

The success of the Binet Scale as a measure of intellect is due to the fact that the intellectual development of children is relatively simple; they have not yet developed a great variety of complex mental traits. On examining all the children in a large school and comparing those of the same age, it is found that fifty per cent of the ten-year-old children succeed in a certain number of these tests. This number is taken as the measure of the average intellectual level at ten years. A child of ten who succeeds in five more tests than the average child of his age, is one year advanced. Children of ten years who only attain the nine-year standard are said to be one year retarded; their 'mental age' is nine years. The same procedure is used in determining the standard for each age.

In applying mental tests to adults a difficulty arises owing to the great individual differences in *breadth*. A man may be highly developed along certain lines and deficient in others. It has not yet been determined satisfactorily how to compare these different attainments with one another so as to represent fairly the individual's mental level. The most satisfactory adult tests at present are those used during the World War in the United States Army. The Army Alpha Tests were applied to about 1,500,000 recruits and officers, and are believed to have successfully rated the intellectual standing of these men.[1]

A mental scale for adults, to be complete, should include separate tests for each independent intellectual trait. It

meaning to do it?" This is answered correctly by the average child of eight years.

[1] The Binet, Alpha, and other tests of this sort are usually called 'intelligence tests.' In point of fact most of them measure only *intellectual* development — not skill, morality, or temperament. An animal maze test would measure *motor* intelligence, or skill.

should distinguish also between traits that have been developed by special training or schooling, and those that grow up under the ordinary influences of social environment. The latter seem to deserve a higher rating. Mere scholarship and information do not denote so high a degree of intellectual development as the less cultivable processes which underlie them.

Mental *tests* differ from school or college *examinations* in just this. An examination in any subject brings out merely the training which the student has had in that particular line; it indicates only in a general way his degree of mental development. A dull person will stand low no matter how much drill he has had in the subject; but except in this crude way examinations do not indicate a person's general mental fitness. Entrance examinations do not show whether the student is mentally fitted to pursue the college course. Entrance tests, if well selected, determine just this point, which is of prime importance in picking out suitable students.

In applying mental tests special care should be taken that the results are truly representative. If the individual tested has been 'coached,' his answer to a question supposed to involve reasoning may be really a feat of memory. A phonograph, supplied with the proper record, might pass a very advanced test and give results indicating a superlative degree of intellect. Such a result would measure the intellectual grade of the individual who prepared the record — not the intellect of the phonograph itself. Unless due care is taken in giving a mental test (or a college examination for that matter), the results may indicate the intellect of the 'coach' — not the mental level of the testee.

A question which interests psychologists at present is whether there is such a thing as *general* intellectual training: Does training in any special line (mathematics, classics, science) result in all-round intellectual improvement? Or is the improvement limited to the trait that is being trained?

The answer is not yet clear. The weight of evidence at present seems to indicate that training is 'specific,' not general. To the extent that two mental traits have a common factor, training in one does improve the other. But there does not appear to be a factor of general intelligence. General intelligence is a combination of many distinct traits.

Temperament. — Temperament is the phase of character which develops out of our desires and emotional attitudes. It is the permanent cast of our systemic life. In general a man's temperament develops quite independently of his intellect. To say that a man is phlegmatic tells us nothing at all about his intellectual capacity.

The reason why these two phases of character are independent is not difficult to understand. Intellect depends on external stimuli, temperament on stimuli which arise from the operation of our inner organs and glands. These two sets of sensory nerves lead to different brain centers, which are not closely related. Chronic indigestion, overdevelopment of one of the ductless glands, oversensitivity to pain, or any other particular internal condition will affect our systemic experiences; this may modify our temperamental character more or less profoundly, but it exerts only a slight influence upon our intellectual growth. What we see and hear serve to develop our intellect, but these experiences of the outer world affect our temperament only to a slight degree. These two sides of human character develop each in its own way. We rate a man's temperament in altogether different terms from his intellect.

The ancients recognized four kinds of temperament, the choleric, melancholic, sanguine, and phlegmatic. This classification was based upon a doctrine of internal secretions which, though in the main erroneous, contained a germ of truth.

Temperament is possibly correlated with the modes of heart action. The heart-beat may be strong or weak, and it may be rapid or slow. Combining these pairs we get four

varieties of temperament, which correspond to the classic types. But this does not take into account the distinction between pleasant and unpleasant feeling, which is really the most significant characteristic of systemic sensations.

A more natural classification is based on both the type of activity and the quality of feeling. The motor side has two phases, active and passive; the feeling element three phases, pleasant, unpleasant, and indifferent. Combining these two groups of characteristics we obtain six varieties of temperament. [Table XVII.]

TABLE XVII. — CLASSIFICATION OF TEMPERAMENTS

Motor Phase	*Feeling Tone*	*Temperament*
Active	Pleasant	Sanguine
	Unpleasant	Choleric
	Indifferent	Mercurial
Passive	Pleasant	Jovial
	Unpleasant	Melancholic
	Indifferent	Phlegmatic

While temperament is not so important a factor in life as intellect or the other phases of character, it should not be overlooked in our study of the mind, nor yet in education. The choleric and to some extent the melancholic temperament are a practical handicap in meeting the situations which confront us in social life. People do not relish having intimate relations with a man who is hopelessly addicted to violent emotions of the unpleasant type — nor yet with one who is perennially grim and sour. It is up to the parent and teacher to train the child away from these unsocial trends, so far as education is capable of molding the temperament.

Systemic stimuli come from the glands and from the internal organs controlled by the autonomic nervous system. The autonomic system works somewhat independently of voluntary control; but it has connections with the central nervous system. Our thoughts affect our digestion and secretions. By deliberately cultivating cheerful attitudes,

we can develop a cheerful temperament. A similar influence is exerted by social example and systematic education.

These influences do not entirely solve the problem. The real solution is to *train our internal organs to work properly.* This is partly the task of the physician. Whether by drugs or by diet or by baths and other agencies, it lies within his power to modify the temperament to a far greater extent than can be accomplished through the central nervous system. The individual himself can coöperate here and in many cases can accomplish the results alone. Regular habits of eating, plenty of physical exercise, a proper amount of sleep, will keep the normal body in good working order and develop the temperament in the right direction.

Skill. — Skill is the phase of character which develops out of our motor attitudes and habits. It is the permanent molding of our 'response' life. A man's motor character is rated according to the effectiveness of his muscular activity; and this rating is distinct from the measure of his intellect and temperament. Like intellect, skill develops in two dimensions: breadth and height. The breadth of skill is measured by the number of independent motor acts that the individual can perform. Its height is the degree of success in performance.

The remarkable *breadth* of motor development in civilized man will be realized if we attempt to make a list of the common acts of modern life. The catalogue would include such varied acts as eating, moving about, dressing, writing, drawing, conversing, playing games, and a host of other performances. Besides these common activities each trade and technical profession has its own particular motor program. In comparing the motor character of individuals, and in rating the comparative development of various races, breadth of skill is an important factor to consider.

On the other hand, *height* — the man's degree of success in performing any particular kind of act — furnishes a more ade-

quate index to skill. In determining height of motor attainment two separate factors must usually be measured: *speed* and *accuracy* (ch. xi). In tests of skill we seek to determine (1) the time required to perform the act, and (2) the number of errors made, or amount of inaccuracy.

It is often difficult to estimate the relative value that should be assigned to these two factors. In certain kinds of work accuracy or precision is of far greater importance than speed; in other cases the opposite is true. A telescope lens must be ground to the utmost limit of accuracy, regardless of time expended. A ready-made garment on the other hand must be finished quickly, in order to reduce the cost of production; irregularities in the cutting are taken as a matter of course.

Sometimes the conditions are such that speed and accuracy are combined into a single factor. In a certain tapping test the individual is required to insert a plug into a series of holes in succession, and to do it as rapidly as possible. Each insertion produces an electric contact and makes an audible click. If the subject misses the hole at first he must correct the error before proceeding to the next hole. Here the inaccuracy factor is eliminated entirely, and speed is the only variable to be measured.

A scale of skill, like the scale of intellect, should include a great variety of typical acts of various sorts, if it is to indicate breadth as well as height of attainment. Up to the present the construction of a measuring scale for skill has not progressed so far as the scale for intellect. The importance of intellect seems to have been somewhat overemphasized in modern civilization. We are only beginning to recognize that skill is an essential phase of human character.

The education of skill belongs largely to technical schools and institutions for manual training. But some progress can be made at home. Boys should be taught to drive nails, saw straight, and perform the common motor activities of

every-day life with accuracy. The home training of girls in the household arts is more advanced, though it still leaves much to be desired.

Games of skill, such as baseball, billiards, golf, and tennis, furnish good training in the fundamentals of motor accuracy. A general system of motor education, corresponding to the intellectual education of our primary and secondary schools, remains to be developed. It is one of the great tasks of the present-day educator.

Morality. — Morality is the phase of character which concerns a man's relations to his fellows. It depends upon our family and social life. There are no separate receptors or senses for social stimuli. All our information regarding our fellow men is received through the external senses of sight, hearing, touch, and the rest.

Owing to the peculiar relations in which human beings stand toward one another, our perception of other persons arouses within us certain special kinds of emotions and sentiments, and leads to *social responses.* If you soothe a sick child, or give a coin to a beggar, or rescue a drowning man, the act is due to a social feeling within you. Your plunge into the river to save a man is a different sort of act, mentally speaking, from the plunge you take for mere pleasure, though the muscular activity in the two cases may be similar. In a word, our social relations develop social attitudes, and these attitudes develop a new phase of human character, called moral character or *morality.* So important is this side of our mental life that in popular language the word character is often equivalent to moral character.

Moral character, like intellect and skill, develops in two dimensions: breadth and height. Our range of social relations extends gradually with the progress of civilization. It includes two separate fields: the family, and the tribe or social group. Family relations include several sorts: marital, parental, fraternal, and filial, each of which involves a num-

ber of separate *duties*. Community life gives rise to many relations with corresponding duties: friendship, business and other economic dealings, community organization, and the general relationship of man to man. As civilization develops and the social organization is perfected these relations are extended, giving rise to broader relations and duties — toward our country, our race, and mankind.

More significant than the range or breadth of social relations is the degree to which an individual enters into these relations. The height of a man's moral character is measured by the extent to which his social ideals and acts tend to benefit his fellows and avoid doing them injury.

Social behavior is called *conduct*. A man's moral character is measured practically by his conduct — by what he does and what he neglects to do. The rating is not determined by what one actually accomplishes but by what he *intends* to accomplish. The psychologist and moralist measure conduct in terms of the man's *motives*, not in terms of the motor result. When you give a dollar to a beggar you may actually start him on a debauch or help to settle him in a life of idleness and uselessness; yet the motive of the gift may be thoroughly good. It is this that makes the true rating of moral character particularly difficult. A scale of morality must take into account not merely a man's explicit conduct, but the attitude underlying his actions; and this involves a determination of his social thoughts, emotions, and sentiments.

Religious conduct and character are closely related to the social. The religious side of man's nature is a striving to propitiate some higher being or beings, to be guided by an all-powerful and all-wise personality, to commune with God. Religious rites and practices belong to the same phase of mental life as social conduct; religious attitudes develop in much the same way as social attitudes. The code of ethics differs from the religious code, but the mental basis of the

two is the same. Man's religious character develops with his social growth rather than with his intellect or temperament.

Moral character is quite susceptible to social training. The child starts life with an inherited social tendency; he also inherits very pronounced self-preservative tendencies which often conflict with social ideals. The first duty of moral education is to foster the child's social trend and repress his self-seeking tendencies.

But this is not all. The child at the outset is quite ignorant as to *what* acts are moral and what are immoral. Left to himself he may work out the fundamental distinctions in the course of time. The function of moral education is to *shorten the learning period*, and to instill in the child many social customs, some of which rest on convention rather than on natural human relations. He is taught to speak the truth, not to take the property of others, to say he is sorry when he has unwittingly done wrong. The conventions of decency and politeness are pointed out to him concretely before he is old enough to appreciate their meaning or place in life. The tendency of the human mind to generalize helps the learning process immensely. A few instances are usually sufficient to teach the child what society expects of him in any given sort of situation.

The responsibility for moral training rests largely with the parents; for the home life presents a vastly greater variety of social relations and far more opportunities for moral or immoral conduct than are found at school.

Reward and Punishment. — Character training in all phases of character is partly a matter of natural mental growth, partly a matter of example and education. The incentive of *reward* and the deterrent effect of *punishment* have always been extensively used in education. Rightly handled these two instruments are very effective in speeding up the training. A word of praise when the child has mas-

tered an intellectual problem or controlled his temper, serves to fix the successful response; a word of disapprobation often obviates a repetition of some wrong-doing.

The danger in the use of reward and punishment as a method of training children lies in a wrong conception of their psychological meaning. We must look upon them solely as *means for developing the child's character*. The old notion of punishment was that when a child makes a misstep he must *pay a penalty* for his error. Psychologically this idea is all wrong. The child has only limited experience; his mental powers are undeveloped. It is to be expected that he will fail more often than he will succeed, whether in intellectual problems, in temperamental demeanor, in problems of skill, or in moral acts. To make him suffer for these failures is wretched pedagogy. He needs assistance, not reprobation. But the inhibitive power of pain and discomfort is strong. If the child cannot make the proper nervous and mental adjustments without a pain incentive, the use of punishment is justified. An admonition or a whipping clinches the warning and often prevents a repetition of the same mistake. The danger in applying this method too frequently is that the child may come to regard the parent and teacher as an agent for retribution instead of a guide. Punishment of any sort should be used sparingly and only when other means of training have failed.

The use of reward has its dangers also. It may serve to make the child careless, or he may strive for the reward itself, instead of aiming for successful *development*, which is the only psychological justification for rewards. This is true even in later life. Not infrequently the college educator finds his students inquiring whether their grades are high enough to qualify them for Phi Beta Kappa. The question shows that they are working for the symbol of success — not for the mental attainment itself. Rewards should perhaps be used merely as a counterbalance to punishments. If a

child needs no punishment he probably needs no reward — except of course the expression of friendly sympathy, interest, and comradeship on the part of his parents and teachers.

Summary. — Experiences leave traces, and these traces tend to consolidate into *permanent mental conditions.* The first step in this process is the development of *attitudes*, due to the frequent repetition of similar experiences. The fundamental attitudes are *interest*, *desire*, and *attention*, which grow out of external, systemic, and motor experiences respectively. Among the complex attitudes, the *dispositions*, based on our emotional life, are most significant.

Attitudes consolidate into more general trends called phases of *character*. The attitudes which grow out of external experiences enter into our intellectual character or *intellect;* systemic attitudes build up our *temperament;* motor attitudes regulate our *skill;* social relations build up a fourth phase of character, called *morality*. All these are subject to growth, and except in the case of temperament they develop in two dimensions: height and breadth. Mental scales serve to measure a person's mental development in comparison with other individuals. The intellectual phase of character has been most successfully measured.

PRACTICAL EXERCISES:

75. Compare the direct effect of the stimulus and the influence of your attitude in reading a novel, in watching a ball game, in discussing some question with a friend.
76. Analyze the attitude of pique ('being peeved') in yourself and others, including its characteristic manifestations; also the jealous and cautious attitudes.
77. Examine the report of some important congressional or legislative debate; determine to what extent the attitude of the participants was conciliatory, accusatory, and judicial.
78. Test children from four to twelve years old for the number of figures and words (syllables) which they can repeat successively after one hearing. Report the progress according to age.
79. Analyze your temperament, and compare it with that of some intimate friend.

80. Examine what has been the effect of punishment and reward on your mental and moral development.

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CHAPTER XVI

PERSONALITY AND CONTROL

Nature of Personality. — Personality is the entire mental organization of a human being at any stage of his development. It embraces all four phases of human character: intellect, temperament, skill, and morality, and every attitude that has been built up in the course of one's life.

Stimuli are constantly pouring in upon you; in a broader way, situations are constantly affecting you. How do you 'take' them? Your behavior is the joint product of (1) the nerve impulses that penetrate to your centers and (2) your entire mental organization. This second factor is your personality.

Personality is not inborn and unchangeable. It is a gradual growth. We are very different persons at five, at fifteen, and at twenty-five. The difference is due to the fact that we are all the time gathering in new experiences and assimilating them. The ground-work of personality is inherited. Every creature inherits a nervous system of a certain type, with certain possibilities and certain limitations. The brain and nervous system of the lower species are too simple to permit the development of language or thought. The normal human being is born with a complex and plastic brain, so that he is capable of learning to speak and think. Given the right sort of nervous system to start with, the power of speech and thought is developed through repeated experiences. Our personality is broadened or heightened as each new sort of experience is acquired; it continues to grow and expand throughout our lifetime.

It is more difficult to rate a man's personality correctly than to measure any single trait or any phase of his char-

acter. You think you have sized up a certain friend of yours pretty accurately. A crisis brings to light some unsuspected strength or weakness. The retiring, timid fellow shows a grit, a perseverance, a boldness perhaps, with which you never credited him. The steady, masterful man suddenly goes off the handle. Why? Because of some streak in his personality which has not hitherto been connected up with his 'general self.'

If personality were merely intellect — or any other special character — it would not be difficult to determine a man's future development at the age of twenty. But our contest with the environment often takes unexpected turns, which call into play every side of character. Our temperament influences our intellectual growth and our moral development. They may work together or at cross-purposes. A critical situation may find the weak spot in our armor; or a combination of fortunate circumstances may develop strength in every part of our equipment and make us conquerors. A well-rounded personality is one that enables us to cope with all the usual situations in life. Overdevelopment in one direction may be as disastrous as underdevelopment.

Attempts to measure human personality scientifically have met with little success. Most of the essays and books on personality are written by amateur psychologists, who have no appreciation of the real problems involved. They emphasize certain striking *individual* features, or deal merely with a few distinctive traits of character. The trained psychologist is apt to shirk the problem altogether. There is an excellent reason for this. Before we can measure personality we must determine the relative importance of the distinct phases of character that make up personality. This is a difficult task. In a general measure of human mentality what proportion should be assigned to intellect? How much should temperament, skill, and morality count? The only satisfactory solution, apparently, is to value each factor

according as it assists in adapting our behavior and mental organization to the external conditions of life.

Personal Identity and Multiple Personality. — In normal human beings, the whole mental life is organized into one continuous chain of complex experiences. The greater part of your past experiences may be brought into relation with the present if the proper nerve connections are made. Your conscious life stretches back as far as you can remember, and every event that you recall is felt to belong to one and the same *self*. Your present thoughts and feelings and activities are tinged with a scarcely describable element which may be called a " sense of ownership "; they *belong to you*.

This sense of the *me* and *mine* is your experience of *personal identity*. The feeling of personal identity arises from the fact that ordinarily the whole mass of an individual's experiences belong to one continuous series; his mental life, though complex and intricate, is a *unity*.

In certain cases this unity of self is broken. Groups of experiences may be dissociated from the general mass and organized into a more or less definite personality of their own. This happens most noticeably in disorders of the central nervous system, such as hysteria. But there are also cases in normal life. Many of our subconscious mental processes are ' split-off ' experiences.

When you carry on two acts at once, such as eating dinner and making plans for the next day, or knitting and talking, the two activities are probably controlled by two separate systems of mental organization. Individuals susceptible to trance or hypnosis may be absorbed in conversation and at the same time may write automatically on some entirely different topic without knowing it. When we have planned out beforehand the itinerary of a walk and carry out our program without thought, the succession of actions is probably controlled by a subconscious organization. These are typical cases of subordinate consciousness or *secondary personality*.

There are occasionally pathological instances where the secondary personality becomes so completely organized as to form a separate self. This is called *co-consciousness* or *dual personality.* The secondary self has developed into a coördinate primary self. The patient leads two distinct lives, one alternating with the other. Sometimes in one state he has no memory of his experiences and doings in the other state; or state A may be remembered in state B, but not the reverse. The temperament and moral character of the two personalities may be quite different. Pierre Janet and Morton Prince have studied cases in which three or more alternating personalities — all strikingly different — appear in the same person.

There is something fascinating to most of us in the study of these unusual phenomena. The casual observer regards them as weird and uncanny — perhaps as demon-possession or manifestations of a mysterious spirit-world. To the student of psychology all these instances, whether of secondary personality or of dual personality, serve to emphasize the general unity of the self. Multiple personality is the exception. In most persons experiences are woven together and organized into one single personality.

The Notion of Self. — Our self-notion arises in connection with this unity of personality. It grows out of sensations *especially connected with our body. The child perceives his* own body through the external senses, and he has a mass of organized systemic and motor sensations from within the body. All the sensations and ideas which refer to his own body and its activities combine into a general *self-perception* or *self-feeling.* This is not a 'notion' but a sensory experience.

As thought and language develop in the child, a name is attached to this self-feeling. At first the child calls himself 'Baby,' or uses his own name: "Jack is hungry"; "Show it to Baby." His own personality stands on the same footing

as that of other human beings. This first step toward the self-notion may be called the *objective* stage.

When the child learns to use pronouns (*you*, *I*, *he*) the notion of self becomes sharply distinguished from the general notion of 'human beings.' This second step is the *subjective* stage; the child has begun to recognize the special relation of his own body and its activities to his own conscious experiences. The true self-notion dates from this stage. It develops constantly throughout life, especially among civilized and reflective beings.

Finally, the child discovers a personality, with experiences like his own, in other human beings; he even reads it into lower animals and inanimate objects. The child punishes the naughty chair that tipped him out; older people treat a dog as if he could reason. This *ejection* of our self-experiences into others is a third stage in the growth of the self-notion.

The notion of self is not a special, higher stage of mental development, as is commonly imagined. Self-consciousness [1] runs through all stages of mental growth, but it only begins to acquire distinctness when language and thought appear, and the difference between *I* and *you* comes to be recognized.

General Problems of Personality. — In studying any science we necessarily proceed in a piecemeal way. Each element and factor must be examined separately before we can attempt to study their mutual relations or their bearing on the whole subject. This is especially true of psychology. First we study the nervous system, then the various senses which furnish the material out of which our experiences are formed. Then we examine one by one the various kinds of experiences and types of behavior. The real study of mental life begins when we examine the succession of experiences and the principles of their connection. Finally we investigate

[1] Self-consciousness in psychology means *consciousness of our own personality;* this meaning should not be confused with the popular use of the term, to denote *embarrassment.*

the permanent mental conditions which mold our mental life into an enduring self. Our attitudes grow up out of single experiences, constantly repeated; the consolidation of similar attitudes results in the organization of our several character-phases; and the final outcome is our personality or self, which includes our entire mental organization.

In the course of this study several general problems have no doubt occurred to the reader which are of more than theoretical interest. Every one of us asks himself at one time or another to what extent his personality is fixed by heredity, and how far it is molded by his special environment. We often wonder at the great differences that appear between different individuals. The most practical question of all is how far we can mold our own lives and control our environment. These three great problems of personality may be stated as follows:

> What are the factors in *mental organization*?
> What different *types of mind* are found in man?
> To what extent do we personally *control* our environment and the course of our own lives?

Mental Organization. — The term *organization* is applied to any complicated structure whose several parts perform different operations but all work together to accomplish some definite result. A locomotive is an organization; its various parts do different things, but all parts coöperate to make the machine go and to regulate its movements. Living creatures are organizations [1] whose organs perform different vital processes, but all work together to maintain the life of the creature and perpetuate the species. The social organization of man has the same general characteristics; a government or an industrial concern includes many human beings who perform different duties, but they all coöperate to accomplish certain general results.

Our mind, or mental organization, is the joint product of

[1] This particular kind of organization is called an *organism*.

two distinct sets of factors: (1) An inherited physical structure consisting of the nervous system with its receptors and effectors. (2) Acquired experiences and modifications of this structure due to stimuli and other forces which act upon it. Examining more closely, we can break these up into six separate factors:

Inherited structure

Terminal organs and conducting nerves
Central nervous system

Effects of external and internal forces

Disorganizing influences
Stimuli and general surrounding conditions
Social influences
Educational influences

a. TERMINAL ORGANS AND CONDUCTING NERVES: The receptors and effectors are the two terminals of the nervous system. These terminal organs, joined together by chains of connecting neurons and intermediate centers, are responsible for the great diversity in our experiences.

The wealth of different sensations which we get in sight and hearing is due to the complexity of the eye and ear. No matter how many kinds of stimuli existed in the environment they would all give us the same kind of sensation if the receptors were not constructed in such a way as to receive them differently. The number of different sensations we are capable of having depends on the degree of development of our sense organs. Color blindness shows how the number of color sensations is lessened when the eye is imperfectly developed.

In the same way the variety of different motor responses that we are capable of making depends on the multiplicity of muscles and glands. A game knee or a stiff finger-joint will interfere with a surprisingly large number of coördinated movements. Notice how a glove on the hand hampers many simple manual tasks. Notice what a number of muscles all

over the body are concerned in the movements of rising to your feet and in keeping your equilibrium. Clear pronunciation and the varied intonations of the human voice require the coöperation of numerous muscles of the jaw, tongue, lips, cheeks, throat, and thorax.

The motor organs are more substitutive than the receptors. If certain muscles are wanting we can often develop some other combination that will serve the same purpose. A man born without arms may be trained to use his feet for hands and his toes for fingers. But this motor substitution has definite limits. No group of human muscles has succeeded in accomplishing aerial flight. Nothing in the lower animals quite takes the place of the human thumb.

The conducting nerves may be regarded as part of the receiving and reacting machinery. The sensory nerves convey the impulses from receptors to centers. If there is a break anywhere in the chain, the information is not received. In the same way the motor nerves convey motor impulses from the centers to the effectors. They are part of the 'motor mechanism.' In short, the inherited terminal organs and conducting nerves determine the number of different sensations that a man can have, and the number of different responses that he can make.

b. Central Nervous System: The central nervous system is the most important part of our mental endowment. It is the means by which we put together the mosaic of information and use it effectively in our actions. Even though our receptors are defective, or if some are entirely lacking, we can often get equivalent information from other senses, so that we can meet the ordinary situations of life effectively. The blind and the deaf can think and reason as well as the normal person if their central system is unimpaired.

The same is true on the motor side. It goes without saying that there can be no movement without muscles; but the coördination and fine adjustment of muscular movements is

brought about by the central nervous system. A study of handwriting will demonstrate this. First write a phrase in the ordinary way; then write it in very small letters, using only finger-movements; finally write the same phrase in large letters on the blackboard, keeping your wrist and fingers rigid and using only the elbow and shoulder. In the two last cases entirely different muscles are used; yet there is a marked similarity between all three results. [Fig. 80.] This shows that the individuality of a man's handwriting is due to characteristics of the nerve impulses from his brain centers, not to the constitution of his muscles. The reëducation of crippled soldiers demonstrates the same thing in another way. The brain, and in a lesser way the lower reflex centers, are the organs of adjustment. This central system enables us to 'grasp' the environment and respond suitably to the situations presented to us. Man's mental supremacy is due almost wholly to his inheritance of a highly complex *cortex*, furnished with a vast number of interconnecting neurons. Integration of stimuli, coördination of responses, and adjustment of response to stimulation all depend upon the central nervous system and especially upon the cortical tracts. These are all inherited structures.

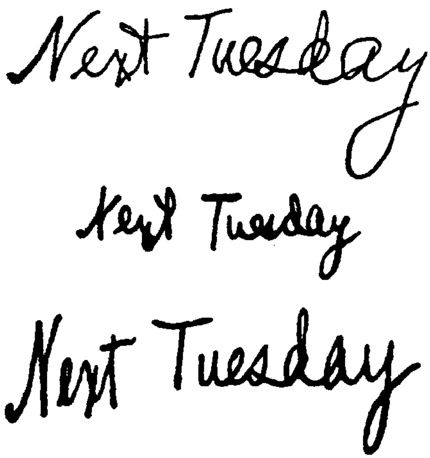

FIG. 80. — HANDWRITING WITH DIFFERENT MUSCLES

The upper writing was made with wrist and fingers. (Slightly reduced in the cut.) In the middle specimen only the fingers were used. The specimen below was made with sweeping movements of elbow and shoulder on a large blackboard; wrist and fingers rigid. (Much reduced in the cut.) Although entirely different muscles were used in the second and third, the writings are similar, showing that individuality in handwriting is due to the coördinated motor impulse sent from the writing center in the brain.

c. DISORGANIZING INFLUENCES: The inherited structure which governs mental processes is liable to be impaired in various ways by the destructive action of agencies that lie outside our body. Our eyesight may be injured by overexposure to light or by some sharp body mutilating the eyeball. The loss of a foot or hand cripples our motor expression. Injury to the brain by a fall or other accident often leads to serious disturbance of the adjustive functions.

There are also disorganizing influences within the body itself. A tumor in the brain affects the structure of certain centers or their operation, and this may give rise to pathological mental manifestations, such as aphasia. Malnutrition, disorders of digestion or other vital functions, persistent use of narcotics, stimulants, and other drugs, may alter the course of mental activity to such an extent as to affect a man's character and personality profoundly. Thomas Carlyle's pessimistic attitude is attributed to his chronic dyspepsia. Diseases which destroy the tissues may affect the nerve substance or some of the receptors or effectors. Deafness may be brought on by measles; infantile paralysis impairs the power of locomotion.

All such effects represent the destructive action of the environment on our inherited mental organization, since even the destructive agencies within the body may generally be traced to something harmful in the environment.

We can look at the matter this way: Nature, through our heredity, has furnished us with a splendid apparatus for using our environment to promote our life interests. This apparatus is admirably fitted to cope with all ordinary situations. But it does not provide against every contingency. It is liable to injury and destruction. Yet we can often cope successfully with these disorganizing factors in an indirect way. We can avoid destructive weapons, shun infection, keep our body in good condition by regular living. Even when unfore-

seen or unavoidable circumstances injure the apparatus, our mental and social organization often provides a means of repairing the injury. Medicine, surgery, therapeutics, and education may cure the disorder or train some other organ to take the place of the one that is impaired.

d. STIMULI AND GENERAL SURROUNDING CONDITIONS: Mental organization becomes effective by use. What we inherit is merely the *capacity* for certain reflexes and instinctive actions and the possibility of acquiring intelligent responses. These possibilities become actual modes of behavior only when stimulation occurs. Even the simplest reflex path has to be joined up before it can be used. Unless the proper stimuli occur at a certain period of life the connection may never be made, as we find in the case of the ear-twitching reflex.

Intelligent actions are even more dependent on stimulation. Their nerve paths are not ready for use at the start. The connections are established slowly, by repetition of the same stimuli. We do not inherit language, or thought, or such special activities as house building and automobile steering, in the same way that we inherit walking and eye-movement. Our inherited nerve structure merely makes intelligent action *possible.* The ability to perform the act is acquired and perfected gradually through the working of stimuli upon the nervous system.

There is one striking difference between the nervous mechanism and man-made machines. A machine may limber up and do better work after the first few trials, but after that it does not improve, — and it does not develop totally new uses. One can scarcely imagine a harvesting-machine being converted into a printing-press. Our nervous organization, on the contrary, improves continually by use, and admits of most astonishing adaptations. The human hand, with the nervous system to guide it, is used for tilling the soil, for feeding, and for writing.

In addition to particular stimuli, mental life depends upon certain general and relatively permanent conditions of the environment. Climate and temperature, abundance or scarcity of food, the presence of material for protection and defense, assist in determining what our life shall be.

In short, the course of our mental life and the progress of its organization depend not *merely upon our inheriting* a certain nervous structure, but upon our *using* that structure. The direction of mental development is determined by the action of forces outside and inside the body, working upon the inherited nervous system.

e. SOCIAL INFLUENCES: Social situations are perceived by the very same senses that inform us of things in general. There is no distinct 'social sense.' But social forces differ in many important ways from other external forces, and the situations which they represent play a peculiar part in mental organization. Because our fellow men have a nervous system similar to our own, and because their aims and interests in life are of a piece with ours, social stimuli have a different effect from other stimuli.

Language and the whole process of communication depend upon the presence of a social environment. The development of thought is assisted by the fact that one man's mental processes are much like another's. Our ability to speak readily and think clearly is apt to be impaired by constant seclusion from the world, though alternation of solitary and social conditions often stimulates rational thinking.

The extent to which the development of mental life depends on social influences is shown by certain instances of children brought up apart from human surroundings. In the case of Kasper Hauser, whose early years were apparently devoid of social intercourse, intellectual development was irremediably stunted. He could never be raised above the condition of an imbecile.[1] Helen Keller, cut off from social

[1] This may have been due to hereditary deficiencies.

stimuli through blindness and deafness, made no progress in mental growth till taken in hand by an expert teacher.

Much of our mental growth in childhood is due to subconscious absorption of ideas and imitation of customs from those about us. Our mental organization is molded after the pattern of the community in which we live. An individual with a certain heredity may become a notorious criminal or a power for good, according as he is placed in an unfavorable or favorable social environment. The example set by others excites a molding influence on mental development, even apart from education.

f. EDUCATIONAL INFLUENCES: Education in the sense of organized teaching is a separate factor in mental life. It is the *systematic effort* of society to develop the mental organization of its members.

Teaching occurs in a rudimentary form in primitive races, but its real significance is seen in the higher stages of civilization, where it exerts a tremendous influence in developing the mind. Beginning with home and church training it extends through the schools to the university and to technical institutions of every sort. By means of systematic training mental growth is 'forced' — mental organization develops at a rate far exceeding that attained through the mere influence of social example.

Human personality and mental organization depend upon every one of these six factors. They are all needed in a systematic explanation of what we are and why we think and act as we do. The student of human nature realizes how dependent a man is upon his parentage and surroundings, and is more inclined to sympathize with the dullard, the social misfit, and the criminal than to condemn them. This sympathy should not take the form of mawkish sentiment, but should aim to remedy their disabilities as far as possible.

Education, not punishment, is the means to use. If the

defect is without remedy we can at least find an environment suited to the individual's limitations. The 'lunatic asylum' has given place to the 'hospital for the insane.' There are training schools for the mentally defective, and special classes for dull students. The prison system should emphasize the educational side — especially moral education — instead of the penal side. Applied psychology has an important task before it in picking out suitable occupations for social misfits. A feeble-minded boy who had set fire to several houses was committed to the Vineland institution. They assigned him the duty of tending the furnace. From a dangerous criminal he was transformed into a useful workman.

Mental Types. — When we compare human beings we find striking differences in both the *degree* and the *type* of their mental development. The variations in *degree* of development or mental level are measured by mental tests (ch. xv). Varieties in *mental type* are *qualitative* differences between the minds of various men. Each type of mind represents a predominance of some phase of mental life. The most significant differences are found in *sensory types* and *types of character*.

The differences of *sensory* type have been examined experimentally. One person is found to be preëminently a *visualist*. He is eye-minded. In his case the visual sensations and images are especially vivid and form the most prominent part of his mental experiences. He must see a thing before he can understand it. He learns by reading better than by listening. In science his interest is in the microscope or in maps. If he is an author, his books abound in color terms and visual pictures.

Another person is of the *auditory* type. He is ear-minded. He thinks in terms of the sound of words. He understands oral instructions readily, so that he learns more easily from listening to lectures than from poring over text-books; he is

quick at 'mental' arithmetic. His auditory imagery and in most cases his appreciation of music are developed above the average.

A third belongs to the *motor* type. He is muscle-minded. With him language is primarily a motor phenomenon; he thinks in terms of sensations from the vocal muscles, and his imagery is largely of muscular movements. He is quick at memorizing speeches; his interest is in motor activity. A deaf-blind person is probably of the *tactile* type.

It is a mistake to assume that every one belongs distinctively to one of these types. In some cases the mental organization is rather evenly balanced. In many persons certain activities are preëminently of the visual type while other activities are based upon motor or auditory data. A man may be an 'auditory linguist' in one tongue and a 'visual linguist' in another. He may be a visualist in geometry and of the motor type in physics. The growth of types depends partly on inherited brain structure and partly on circumstances of training. In the earlier stages of education it is important to train the type of imagery and thought along the lines best suited to each particular topic. Later, when we find out the type to which the child naturally belongs, it is wiser to fit the educational method so far as possible to the individual: teach the visualist through books, the audile person by oral instruction.

The growth of character brings out another set of types. In certain persons the intellectual side is dominant, in others temperament, in others skill. When we speak of a *temperamental* personality, we mean that the person referred to is subject to frequent sweeping changes of temperament; this is usually accompanied by deep emotional displays. An *intellectual* man looks at the world from an unemotional, logical point of view; and so on.

There are individuals in whom the various phases of character are mingled, but with a decided bent of mind in

some definite direction. You have no difficulty in distinguishing a timid mind, a nasty mind, a schemer, an aggressive personality, a snobbish nature. Some persons develop traits of manner, voice, and thought such that they are known to every one as having an 'attractive' personality; others seem to be inherently 'uninteresting.' Various other types might be added to the list: the 'slobbery' man, the 'bellyacher,' the dreamer.

The development of these types depends largely on inherited nervous structure; certain brain centers may be more highly developed, or some of the connective nerve tracts. But use and systematic training can foster certain phases of character and check the growth of others. John Stuart Mill seems to have been by nature of the esthetic type. Under his father's rigid intellectual schooling he grew into a pronounced intellectualist. His case is somewhat exceptional in that the drastic training was successful. Usually the attempt to divert a person's mental life into entirely new channels is disastrous. In the interests of the man's happiness it is wiser to mold his character, from childhood onward, along the lines of his natural propensities, taking care only to eliminate any overdevelopment of one side which might hamper his social or moral welfare.

Control. — A question of great practical importance in life is how and to what extent a person can control his own actions and cope with the situations with which he is confronted. The subject has unfortunately been coupled in the popular mind with speculative theories concerning human 'freedom' to think and act. Our study of mental processes has shown that men do not think and act in an arbitrary manner. The succession of thoughts depends on definite principles of association and proceeds in an orderly way — new thoughts are not spontaneously generated. Psychology assumes that voluntary decisions are definitely determined by principles of mental activity, and not by

chance. We never pull ourselves completely away from our own character and personality by sheer will, any more than we can pull ourselves off the earth by tugging at our own boots.

The psychological problem of control has no relation to these philosophical gymnastics. It is concerned with the efficiency of man's mental organization. There are two questions involved: (1) What are the processes by means of which a human being controls, directs, guides his own life? (2) What does this control accomplish?

(1) MEANS OF CONTROL: Every response is an exercise of control. Reflex actions show this control in its most rudimentary form. The reflex wink protects the eye; swallowing carries food to the digestive organs. Many reflexes which taken by themselves have no special significance, are essential parts of organized actions. The autonomic processes of digestion, circulation, etc., are splendid instances of control and regulation, but they are mainly concerned with the maintenance of the body substance and not with our responses to external situations.

The three most important means of control are *instinctive* actions, *intelligent* actions, and the special type of intelligence called *rational* actions.

Instinctive behavior is especially effective in controlling the permanent, stable features of the environment. The bee's honey-gathering actions are useful because there are honey-giving flowers in every bee's environment at certain seasons of the year. The nest-building instinct of birds is effective because there are trees and materials for constructing nests in the bird's environment. The preying activities of some animals and the grazing activities of others are due to certain permanent features of the world in which these animals live.

Intelligent behavior is effective in controlling more changeable situations. Voluntary actions usually deal with situations that are at least partly new. When you catch a ball,

your movements depend on the speed and angle of the ball, both of which factors are open to all sorts of variation. Speaking and writing bring about useful results because we utter or write *different words* according to circumstances. Inventions and social customs spring up from time to time and change continually; we learn to operate machines and to follow social customs by intelligent responses.

Rational behavior is based on the fact that nature is uniform — that physical, chemical, biological, and mental events take place according to permanent, enduring principles; but it depends quite as much on the fact that the situation varies from time to time. The airplane inventor and the pilot who runs the plane must take into consideration both the general principles of aeronautics and the varying conditions which a plane will encounter.

(2) OBJECTS OF CONTROL: What is it that we control? The simplest sort of control is *control of our own responses.* In the case of reflex and instinctive behavior this control is practically complete. Inherited nerve paths enable the creature to make the proper movements from the start. In the case of intelligent and rational actions we learn to control our movements by slow degrees. At first the motor outcome is generally wrong. Step by step we acquire control of our muscles and do what we have planned to do. The process is one of central adjustment. We learn to improve our motor coördinations by means of our higher brain centers. There is apparently no limit to the improvement.

Another variety, slightly different from this, is control of ourselves. *Self-control* is confined almost wholly to man and is due to the development of higher brain centers. Man learns to inhibit or modify his own systemic and motor processes. This is illustrated in the repression of emotion and less obviously in the regulation of our daily work. The special significance of this kind of control lies in the fact that it enables us to govern the course of our own life. This

means a distinct advance in efficiency. To master the tongue — and the fist — is a mark of high mental development. The man who can control himself can usually control others.

A more significant type of control, so far as outward results are concerned, is the ability to modify the environment itself by our actions in such a way as to assist our life processes. When primitive man prepared skins of animals and used them to clothe and protect himself, he advanced a step toward *control of his environment*. The making of forest trails, building of huts, sowing of fields, and domestication of animals are other early instances of man's active influence upon the physical world. Ships, railroads, harvesters, lighting plants, and all the products of modern industry may be regarded as instruments for the control of nature by man.

Along the same line is the improvement of our receptors and effectors by artificial devices. Man has succeeded in overcoming to a large extent the natural limitations of his senses and motor organs. He has devised spectacles, the microscope, and the telescope to supplement his eyes. The telephone extends the range of the human ear. Weighing scales take the place of hefting with our hands; the thermometer adds precision to our temperature senses. Our motor organs are supplemented in the same way. The hammer takes the place of the human fist; the bicycle and railroad train increase man's locomotor ability; the plow, crane, and countless other tools supplement his arms and hands. These measuring instruments and tools may be treated as artificial receptors and effectors, developed by human intellect and skill instead of through biological evolution. They are added means for controlling our environment.

Still another type is *social control*. By means of language a human being is able to guide the actions of his fellows and is guided in turn by them. Your control of other men may

be regarded as part of your control of your environment. But when you yourself are governed by social influences a new phase of control arises. Your own mind is no longer the supreme director of your behavior. The center of control is shifted to some other mind or to the collective influence of the community. The soldier and the hired servant are controlled by other human minds. The office holder in a democratic nation is subject to control by the group. The actions of individuals in any community are determined largely by custom and tradition; to this extent we are all subject to group control.

The growth of our mental organization may be either promoted or impeded by social control. The training of children and systematic education of every sort illustrate the useful side. One is often inspired to better things by the example of others. Psychotherapy is the improvement of bodily and mental conditions by suggestion. The discipline of the workshop and the army are useful on the economic side, though they tend to diminish a man's independence and self-reliance.

Social control is distinctly bad when one individual comes so fully under the domination of another that his mental growth is seriously thwarted. The slave and the professional hypnotic subject illustrate the harmful working of social control. The result here is mental deterioration instead of mental development.

Control is the most significant feature of behavior. Our motor activities are effective just so far as they serve to control our environment or our bodily organization. Civilized man, through the enormous development of his brain, by means of his acquired information and motor habits, and with the aid of measuring instruments and tools of his own devising, is able to guide his own destiny. He learns to govern himself and others. He directs his motor acts and is able to alter his environment to a large extent — to change

the face of nature. He is at once "master of his fate" and "captain of his soul."

Conclusion: Practical Bearings of Psychology. — In this book we have been attempting to study in a systematic way the characteristics of human nature. Man is a being who *experiences* and *acts*. His experiences, we have found, are built up out of sensations obtained through the receptors and nervous system, which inform him concerning his environment. These separate sensations are organized into *perceptions*, *memories*, *emotions*, *thoughts*, *volitions*, *language*, and other definite sorts of experience. The repetition of similar experiences builds up special and general *attitudes*, and these mold the different sides of his *character*. The final summation of our entire experience life is *personality*.

On the active side, mental life starts with isolated responses to isolated stimuli. These separate *reflexes* are organized into *instinctive acts*, and by the learning process they develop into *intelligent acts*, of which *rational action* is a specialized form. By means of these various forms of behavior we come more and more to control our movements, our bodily organs, our fellow men, and the world about us. The final outcome of this progressive organization of behavior is our *personal control of the whole situation*.

There is a special glamour surrounding the mysterious. The conjurer who extracts eggs from your mouth and rabbits from your pocket attracts your interest. The spell is gone when you discover how the trick is performed. The mysterious workings of the human mind arouse our wonder in much the same way. Will this feeling be dispelled altogether when we discover the orderly way in which mental life proceeds? Let us hope not. The study of psychology gives us a clue to the workings of the most wonderful contrivance in existence — a mechanism which has enabled man to collect a tremendous mass of information about the world in which he lives, to use this information for furthering his aims

in life, and to transform the face of nature itself. Should we not feel greater admiration and awe when we realize that *all this is accomplished by means of the same orderly processes that operate throughout nature?*

Our present study has necessarily been limited to fundamental facts and principles. When these are mastered, we are in a position to branch out into more practical fields. If we understand how the grown-up human mind works, we can compare its processes with those of the child mind and with the mental processes of animals.

A knowledge of psychological principles will assist us in our own mental training — in our efforts to form new habits or break bad ones, to govern our passions, to become socially fit, to judge men, to understand their failings.

Psychology has many practical applications. One of its fields is to assist in selecting the most suitable man for any given position — industrial, scholastic, or political. If we know our own type of mind it will help us in choosing our career. The judge and the physician must appreciate the significance of mental deficiency in order to treat their 'cases' correctly. The lawyer and the preacher must understand the workings of the human mind in order to make their pleas effective. In these and other directions a knowledge of *scientific* psychology is of the utmost value.

Every one has some inkling of how the mind works, just as every one has a smattering of chemical and physical facts. But amateur knowledge is a long way behind accurate knowledge. Which of us would undertake, without training, to run a locomotive? Yet the human mind is far more complex than any man-made contrivance. It is true that the mind is to a large extent self-acting. We are capable of meeting situations by our own native power of mental adjustment. But if we wish to use our mind effectively, and if we would cope successfully with the minds of others, our untutored insight and judgment are not sufficient. We must

understand the fundamental principles of mental life as formulated by psychology.

PRACTICAL EXERCISES:

81. Analyze how far your personality appears to be due to heredity and how far to your social environment.
82. Determine so far as possible to what sensory type or types you belong.
83. Describe instances you have observed of the growth of control in various directions — emotional expression, sketching, systematic study, moral conduct; if possible take your own case as one instance.
84. What is your present idea of *mind?*
85. Give instances from your own observation of notably good and bad effects arising from social control of one person by another.

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On the self-notion: J. M. Baldwin, *Social and Ethical Interpretations*, ch. 1.

On multiple personality: M. Prince, *Dissociation of a Personality*.

On applications of psychology: H. Münsterberg, *Psychology, General and Applied*, bk. iii.

REVIEW QUESTIONS

Chapter I

What is meant by mental life? What is the distinction between mental and biological life?

In what way does interplay occur between the creature and his environment?

What kinds of questions do we consider in human psychology?

What is meant by (1) self-study, (2) behavior study, and (3) nerve study?

Distinguish between observation and experiment. How may observation and experiment be used in behavior study?

Describe the various branches of psychology.

What branches of psychology might undertake a study of play? (Give reasons why each should be included.)

Define human psychology, and describe the method of study used in this book.

Chapter II

Mention six different kinds of cells in the human body.

How does a neuron differ from a muscle cell?

Describe the axon.

How are neurons connected together?

Name the parts of the cerebrospinal system.

Distinguish between sensory and motor peripheral nerves.

Distinguish between spinal and cranial nerves.

How do sensory nerves enter the cord? How do motor nerves go out of the cord? Where do sensory and motor nerves join?

What is the gray matter in the spinal cord? How do you account for the H shape of the gray matter?

How does a nerve impulse pass from the left side of the body to the right side of the brain?

Describe the medulla oblongata; the cerebellum; the pons Varolii; the basal ganglia; the cortex.

Where are the centers for moving various parts of the body located in the cortex?

Describe the position of the several lobes of the brain in relation to one another and to the fissures.

Distinguish between projection centers and association areas.

Describe the autonomic system. How is the autonomic system related to the cerebrospinal system?

Chapter III

Describe a simple nervous arc.

What are the five successive steps in every case of nervous activity?

Describe the course of the nerve impulse in the nervous arc when an insect lights upon your hand and you turn your eyes to look at it.

How is a nerve impulse started, and what determines its intensity and quality? (Illustrate in the case of a sound.)

What is meant by excitation?

What is the peculiarity of conduction along a nerve fiber?

Point out the difference between retention and fatigue in the nervous system, giving an example of each.

What are the properties of collection and distribution?

Why are our actions called responses?

Distinguish between muscular and glandular responses, and describe just what occurs in each.

What is meant by (1) integration, (2) coördination, and (3) adjustment?

Describe the adjustment process at any moment in the case of some one reading music and playing it on the piano or violin.

CHAPTER IV

Give a classification of the senses.

Describe the structure of the eye.

Describe the various motor functions concerned in sight.

Describe the process of focusing light on the retina. How do near-sight and far-sight affect this process?

Explain the relations between changes in hue, shade, and tint.

How are color relations shown on the color spindle?

What are the primal colors and how do we determine this fact?

What is meant by complementary colors?

Distinguish between positive and negative after-sensations.

What is color blindness? Describe its most common form and how it may be tested.

How does the Ladd-Franklin theory of sight reconcile the three fundamental colors with the four primal colors?

CHAPTER V

Describe the arrangement of the middle ear and cochlea.

What differences in the stimuli for hearing produce (1) deep tones, (2) shrill tones, (3) loud tones, (4) faint tones, (5) noises?

Distinguish between absolute pitch and relative pitch.

How are overtones produced? What is timbre?

Explain how beats and difference tones are produced.

Describe the receptor and stimuli for smell.

Describe the relation of the various sorts of odors.

Describe the receptor and stimuli for taste.

How do you account for differences in the flavor of foods, if there are only four qualities of taste?

Describe the receptors for cutaneous sensations. Name some of the qualities of touch sensation.

What evidence have we that touch, warmth, cold, and pain are distinct senses?

Mention some of the principal organic sensations and discuss the sensation of hunger.

What is the stimulus for pain, and what is the pain receptor?

What information is furnished by the muscle sense?

Describe the receptor for the static sense.

What evidence have we that the semicircular canals are receptors for static sensations?

Distinguish between the external, systemic, and motor senses.

Discuss the relative importance of the different senses.

Chapter VI

If consciousness is not a concrete thing, how can it be studied?

What is meant by impression and suggestion?

Show the relation between retention and revival.

What is meant by attention?

What is meant by fusion and colligation?

What is meant by discrimination?

Distinguish between a sensation and an experience.

What kinds of experiences are composed of a single class of sensations?

What three faults are found in the writings of psychoanalysts?

Give an example of subliminal consciousness.

Describe an experience occurring in the subordinate field of consciousness.

Describe conditions of anesthesia and hyperesthesia.

Chapter VII

What is the relation of perception to sensation?

Why do perceptions sometimes fail to indicate the real relations of external objects?

Why is the difference between 64 lbs. and 62 lbs. less noticeable than the difference between 4 lbs. and 2 lbs.?

Explain Weber's Law.

What factors are involved in the perception of surfaces?

Describe the chief factors in the visual perception of depth with one eye.

How does the difference between the two eyes assist in our perception of depth?

Why does the stereoscope give the illusion of depth?

What is meant by projection?

How does the space perception of the blind differ from that of normal persons?

Describe Stratton's experiment on reversing the field of vision. What light does it throw on space perception?

Explain how we perceive motion and actions.
Why do we overlook misprints and misread printed words?
How do you account for the Hering (or the Müller-Lyer) illusion?
What activities of the central nervous system are involved in perception?
What sort of training is useful to improve perception?

Chapter VIII

Why do we seldom have images of systemic and motor sensations?
Distinguish between memory and imagination.
What nervous conditions and processes are essential to memory?
What is meant by *projection* of memory images, and what does this projection accomplish?
What is meant by the feeling of familiarity?
Explain the laws of association, with examples of each.
How does the rate of forgetting change with the length of time elapsed?
Give three reasons why you forget.
Why does the strength of memory depend on the training of perception?
Why do children confuse their fancies with their recollections?
Distinguish between fancies and anticipation images.
How do general images differ from memory images?
How do we distinguish mental images from perceptions?

Chapter IX

Distinguish between intellectual and affective experiences.
How is the special quality of a systemic sensation related to its feeling tone?
Under what conditions can we experience two conflicting feelings at once?
If feelings are experiences in which the systemic sensations are the main elements, how do our perceptions of external things come to have a feeling tone?
Distinguish between appetite and aversion.
How does the intensity of feeling vary with increased intensity of stimulation?
Distinguish between feeling and emotion.
Explain the James-Lange theory of emotion, and mention some of the evidence for and against it.
How far can observations of emotions in animals be used in the study of human emotions?
Describe the most primitive emotions.
Discuss the classification of emotions given in this chapter. Why is it difficult to classify emotions?
To what extent are the emotions unsuited to civilized conditions?
Are beauty and power in the objects or in the mind?
Describe the sentiments of belief, disbelief, and doubt.
Why are sentiments generally unimportant in mental life?

Chapter X

What is the relation between a motor experience and a response?
Demonstrate the fact that every stimulus tends in the end to bring about some response.
Distinguish between diffused movements and reflexes.
In what respects do the autonomic functions belong to psychology?
Distinguish between lower and higher reflexes, giving an example of each.
Describe the various relations that may occur between different muscles concerned in compound reflexes.
Explain the scientific notion of instinct, and compare it with the popular notion.
How do instincts originate in any species, according to the theory of natural selection?
Discuss the classification of instincts given in this chapter.
Why has man very few pure instincts and many modified instincts?
Distinguish between the clothing instinct and the modesty instinct.
Discuss imitation.
To what extent are instincts present at birth?
To what extent does your present behavior rest on an instinctive basis?

Chapter XI

Distinguish between the effects of fatigue and adaptation.
Describe the way in which a conditioned reflex is acquired.
Describe the transition from instinctive to intelligent behavior.
How is acquisition related to fixation?
Explain the nervous processes involved in acquisition.
Discuss the effect of repetition, intensity, recency, and conflict on the fixation process, with examples of each.
How may the laws of speed and accuracy in habit-formation be demonstrated experimentally?
Criticize the theory that habits are lapses of intelligence.
Describe an instance of trial-and-error learning, (*a*) in the case of an animal; (*b*) in man.
Describe the method of learning through associative memory.
Show by two examples how complex habits are made up of simpler habits.
How may habits detrimental to our welfare be broken?

Chapter XII

In what important respect do motor experiences differ from other sorts of experiences?
Describe the sensations found in conations.
Describe reflex conations, instinctive conations, and habit conations.
Distinguish between sensorimotor and ideomotor actions.
Distinguish between conations and volitions.
Discuss the theory that all ideomotor actions are the result of learning.

Explain what is meant by deliberation and choice.
What is the significance of a delayed response?
Explain the statement that when we *will* to do a certain thing, we have a thought of the action, together with certain muscle sensations of effort or memories of such sensations.
In what respect does a purpose differ from other thoughts?
Show how volition assists us to control ourselves and our environment.
Discuss the nature of ideals.

Chapter XIII

Show how a word may tend to replace an image.
What are the special characteristics of language and thought?
Why are language and thought called symbolic experiences?
Explain why language is especially adapted for communication.
Why is speech superior to gesture as a means of communication?
Why is mirror-script difficult to read and write?
Point out how the social environment is a factor in the acts of reading and speaking.
Discuss the special brain centers for language and thought.
Describe the prominent disorders of language.
Show the relation of meaning to rational thought.
Distinguish between meaning and value, with examples of each.
What is the relation of judgment to thought?
Why is rational behavior superior to trial and error behavior?
Contrast the evolution of emotion and thought.
What is the educational significance of the training of thought and language?
Discuss the various levels of the nervous arc and their relation to experience and behavior.

Chapter XIV

In what ways are our present experiences influenced by our past?
To what extent is the simile of the *stream of consciousness* correct?
How is the speed of perception measured?
Describe the method of determining the reaction time of an association.
What factors determine the flow of perceptions?
What are the principal factors that determine the flow of thought?
What secondary influences determine the flow of thought?
In what ways is the flow of thought subject to personal control?
Describe the chief characteristics of dreams and dreaming.
Why are dreams incongruous and absurd?
Describe the characteristics of hypnotic experiences.
How does reasoning differ from ordinary thinking?
Why do our inferences tend to agree with real events and general truths?
Why do we commit logical fallacies?
Why are our inferences sometimes wrong when we reason correctly?

Explain what is meant by rationalization.

Describe how the various sorts of experiences enter into the general stream of mental life.

Chapter XV

What is meant by a permanent mental condition?

How are mental attitudes built up?

Discuss the relation between interest, desire, and attention.

What classes of experiences arouse interest?

Distinguish between want and satisfaction.

How are emotional dispositions related to emotion?

Describe the problem attitude.

How far does a moral attitude depend on mental development, and how far on social tradition?

Point out the relation of character to attitudes and to experiences.

How are the phases of human character related to the several classes of sensations?

Distinguish between height and breadth of intellect.

Describe the principle of the Binet-Simon tests.

How is temperament related to feeling and activity?

Why is it desirable to have ratings of skill?

Distinguish between motives and the actual results of moral conduct.

Discuss the psychological theory of reward and punishment.

Chapter XVI

Why is it difficult to measure personality?

Describe the experience of personal identity.

What are the characteristics of multiple personality?

Trace the growth of the notion of self.

What is included in mental organization?

Why is the central nervous system more important in mental life than the receptors and muscles?

Mention some of the disorganizing influences that hinder mental growth.

To what extent are stimuli helpful in building up mental organization?

Distinguish between social and educational influences on mental growth.

Distinguish between the visual and auditory types of mind.

What is meant by a temperamental personality?

How does intelligent behavior assist us in exercising control?

Distinguish between control of our own responses and control of the environment.

Point out the benefits and dangers of social control.

How does psychology help the lawyer and the judge? the physician? the employer? the educator?

SUGGESTIONS IN USING THE BOOK

THIS text is intended for use in a full-year introductory course; it may be used in a half-year course with certain omissions.

The chapters generally cover about the same amount of material, the longer ones being somewhat easier, and the shorter ones more difficult. For a briefer course the sections on the structure of the eye and ear (chs. iv, v) may be omitted. To equalize assignments the latter part of chapter vii (illusions, etc.) might be postponed and taken up in connection with chapter xii; it would *not* be advisable to omit or curtail the discussion of the structure and operation of the nervous system (chs. ii, iii).

The REFERENCES at the end of the chapters are limited to special topics of general interest, about which the student might wish to seek further information on his own initiative. They should not be assigned for required reading.

The PRACTICAL EXERCISES are intended to train the student in first-hand observation of mental phenomena. The author has found them to be the most useful part of his own courses. One exercise is required of the student every week. The class is given an option between two or three exercises; one of the alternative exercises is within the experience of every student (e.g., Exercises 1, 2), another may deal with some special topic and be available to certain students only (e.g., Exercises 4, 21).

The exercises should be handed in regularly and promptly. Their usefulness is greatly diminished if they are performed weeks after the topic has been under discussion. Aside from a deduction of credit for tardiness or obvious carelessness, it is not advisable to grade the exercises. If an exercise is per-

formed seriously and handed in on time, it should be accepted and given full credit, however amateurish the result.

The length of the report need not be prescribed. Often a brief report of two hundred words is more satisfactory than a long essay. The point to insist upon constantly is that the student shall *make each observation for himself*, and not rely on his general information or on popular tradition, or repeat the descriptions contained in the book. The form of the report should embody this idea. It should be in the first person: "I saw so-and-so"; "The movements in my face and head were —." The instructor should discountenance such expressions as, "When one says the word *man* aloud, he —." The short-story style, with its artistic embellishments, is tempting to most students, but it is rarely as satisfactory as a plain description. If the exercises are handed back within a week, with a few suggestive comments, it will be found that after two or three attempts most students get the right idea.

It is well to caution the class at the outset against the following sources of error in the exercises: (1) *Careless reading* of the problem, so that its real meaning is not understood. (2) *Careless observation* — especially of familiar experiences. (3) Attempting to *explain* the experiences, instead of reporting them; or mingling an account of what (probably) occurs in the nervous system with the account of what the individual himself actually observes. (4) *Casual observation* in place of measurements where the exercise is in the nature of an experiment or test. (5) Describing the action of children or others in terms of the observer's own *personal experience*, instead of observing and reporting their actual behavior. (6) Substituting *traditional and popular notions* of mental phenomena for the student's own personal observation.

The Review Questions following chapter xvi are intended to assist the student in mastering the contents of the text. They prevent casual reading, by challenging the stu-

dent to explain the meaning of what he has read. The student who has read the assignment but cannot answer the questions is still *unprepared.* The set of questions given here do not include *classifications* or *definitions.* It is doubtful on psychological grounds whether a student should memorize a mere list of terms, such as the table of Emotions. This feat of memory will not advance his knowledge of psychology materially. Definitions are distinctly useful, though a word-for-word reproduction ought not to be insisted on. This type of question is omitted here because abundant material can be readily drawn from the glossary at the end of the book, or from the text itself.

An excellent way of treating definitions in a written examination is by the *completion* method: Print the definition word for word in the examination paper, omitting certain significant terms with a blank in their place. The student has merely to fill in each blank with the proper word — a great saving of time.

The GLOSSARY includes definitions of the principal terms used in this book. The wording is in many cases more precise than that of the text; it aims to bring out the distinction between cognate words. Carrying out this idea, the popular use of certain terms is contrasted with their special meaning adopted in this book. A few useful technical terms not found in the text are included.

It is suggested that the student consult the glossary for terms which come up constantly in class discussions, if the meaning is not entirely clear. The page references include only the principal treatment of a term. Where the reference covers several pages, the number is followed by 'f' or (where a large section is involved) 'ff'; 'n' after a number refers to a footnote. Those interested in the finer meanings of terms are advised to consult Baldwin's *Dictionary of Philosophy and Psychology.*

The principles of psychology have many practical and per-

sonal APPLICATIONS. Both in examinations and in the oral quizzes the instructor will find it useful to ask questions which bring home to the student the intimate relation of psychology to every-day life: "Describe the emotions you experience at a ball game"; "How does the nerve impulse travel in your body when you hear a sound and turn your head toward it?"

Interest in the course will be greatly increased if frequent CLASS-ROOM DEMONSTRATIONS are introduced. Models of the eye and ear are almost essential to an understanding of the structure of these complex organs. A human brain or a model (as in Fig. 1) should be exhibited if possible; also microscope slides showing sections of the brain and spinal cord, and of different types of neurons.

A simple experiment in habit formation or memorizing can readily be made in class. The chain reaction (Exercise 71) can be performed in groups of ten to twenty persons even without a stop-watch. Association experiments can be made with two or three volunteers and their results compared. Many other demonstrations, such as optical illusions, stereoscopic vision, color-mixing, overtones, etc., can be arranged without an elaborate outfit.

Where funds are available for special APPARATUS, and the schedule allows time for experimental work in connection with the course, one of the standard laboratory manuals should be consulted. For experiments requiring practically no apparatus, see Seashore's *Elementary Experiments in Psychology*. Excellent experiments with a few special apparatus are found in Langfeld and Allport's *Elementary Laboratory Course in Psychology*. A great variety of experiments and demonstrations are collected in Sanford's *Course in Experimental Psychology*. The most complete laboratory manual in English is Titchener's *Experimental Psychology* (4 Volumes).

GLOSSARY AND INDEX

[*For suggestions as to use, see page 395*]

Ampulla = an enlargement at the base of the semicircular canals, 118
Anabolism = chemical changes which build up the bodily tissues, 112
Analgesia = loss of the pain sense
Anesthesia = (a) a condition of the receptors or sensory nerves in which stimuli fail to arouse sensation, 139; (b) loss of the sense of touch
— in hypnosis, 321
Anger emotion, 213
Anosmia = loss of the sense of smell
Antagonists (*or* **Antagonistic muscles**) = a pair of muscles which move the same member in opposite directions, 51, 232
Aphasia, motor = a phase of mental disorder characterized by inability to speak, 293
— **sensory** = a phase of mental disorder characterized by inability to understand spoken words, 293 n
Apopathetic instincts = instinctive behavior determined by the presence of others in the individual's environment, 240
Appetite = feeling characterized by pleasantness, 206
Appreciation = (a) an attitude embodying the permanent effects of thought and memory, 340 f; (b) commonly: the evaluative attitude, 341
Arborization = the ramification of fibrils at the end of a neuron, 21
Arc, *see* **Nervous arc**
Aristotle's experiment, of the crossed fingers, 164
Association = the succession of one thought or image after another, or of an idea after a perception, 313
— **laws** = a formulation of the manner in which successive ideas arise, 185, 313
— **verbal** = (a) the association of a name (verbal symbol) with something perceived or imagined, 182, 192, 289; (b) association of one word with another through mere similarity in sound, 324
Association area = a region of the cortex composed of nerve tissue connecting projection centers in the same hemisphere, 33
Association time = the duration of that portion of a nervous process which is concerned in association of one idea with another, 311
Associative memory, *see* **Learning**
Astigmatism = a condition of the eye-lens in which the vertical and horizontal curvatures differ, 65 n
Attention = (a) the mental process of focusing certain parts of an experience so that they become more vivid, 128, 333 n; (b) an attitude embodying the permanent effects of motor experiences, 335 f
— **span** = the number of objects distinctly perceived at a single moment, 163
Attitude = the manner in which an individual receives experiences, so far as this is determined by the deep, lasting traces left in the nervous structure by frequent repetition of experiences of the same fundamental type, 331, 332 ff
— **emotional**, *see* **Disposition**
— **ideal**, 344
— **sentimental** = an attitude which embodies the permanent effects of sentimental experiences, e.g. credulity, arising from belief, 338
— **social**, *see* **Conscience**
— classification, 334
— evolution, 343
— subconscious factors, 344
Audition, *see* **Hearing**
Aufgabe, *see* **Problem attitude**
Automatic response, *see* **Response**
Autonomic function = a coördinated chain or group of reflexes in the autonomic nervous system, which actuate the bodily processes of digestion, circulation, etc., 226
— **system**, *see* **Nervous system**
Aversion = feeling characterized by unpleasantness, 206
Awareness, *see* **Consciousness**
Axon (*or* **Axone**) = the long projecting fiber of the neuron or nerve cell, 21

Basal ganglia (*or* **Basal masses**) = masses of nerve tissue in the cerebrum beneath the cortex; they include the optic thalami, corpora striata, corpora quadrigemina, crura cerebri, etc., 30
Beat = a quaver effect which arises when two nearly similar tones are sounded together, 96; *cf.* **Difference tone**
Beauty sentiment, 219
Behavior = action or activity of any sort which results from the operation of the nervous arc in an organism, 225 ff
— **instinctive** = a coördinated chain or group of diverse reflexes which work together systematically, owing to inherited neural conditions, 227, 233 ff
— **intelligent** = a coördinated set of responses whose coöperation is due in part to alteration and improvement of the *inherited neural connections* by individual acquisition, 228, 250 ff
— **rational** = the motor result of rational thought; a specialized type of intelligent behavior, 298
— *reflex, see* **Reflex**
— classification, 225
— levels, 302 f
Behavior study = the study of the manner in which organisms respond to stimulation, 8
Belief = the sentiment or conviction that certain ideas represent real facts or relations, 220, 222
Binet-Simon scale = a graded series of mental tests for measuring intellectual growth in children, 347
Binocular (*or* **Stereoscopic**) **vision** = perception with the two eyes, presenting a single visual field in which objects stand out in relief, 156 f
Black = a visual sensation which arises without the usual light-wave stimulation, 69, 82
Blind spot = a break in the retina to the nasal side of the fovea, where the optic nerve enters the eyeball, 60
Brain = that part of the nervous system which lies within the head, i.e. above the spinal cord, 3, 29 f
— relation to consciousness, 124
Brain-stem = all the brain except the cerebellum and cortex with connecting tracts, 29 n
Brightness (*or* **Value**) = intensity of visual sensations, 71; *cf.* **Shade**
Broca convolution (*or* **area**) = the posterior (dorsal) part of the inferior frontal convolution; the word-speaking center

Callosum (*or* **Corpus callosum**) = a mass of nerve tissue beneath the cortex, which connects the right and left hemispheres, 31, 33
Canals, semicircular = an organ in the inner ear which serves as receptor for the static sense, 87, 117
Catabolism = *destructive chemical changes* in the bodily tissues, 112
Cell = an organized mass of protoplasm in the living body; the unit of organic structure, 19 f
Cell-body = the compact body of a neuron, exclusive of the branches, 21
Censor = a term of doubtful propriety applied to the organized subconscious life, 134
Centers = regions in the nervous system where sensory impulses pass over into motor impulses, 31, 122
— **cortical** (*or* **control, projection**) = regions in the cortex where impulses from or to the primary centers are collected or distributed, 32, 33
— **language** (*or* **speech**) **and thought** = special regions in the cortex (usually confined to the left hemisphere), where thought and language activities occur and where motor impulses for communicative expression originate; they form the adjustment center of the highest nervous arc, 32, 34, 292 f

Commissure fibers = nerve fibers which connect corresponding centers in the two sides of the brain or cord, 33
Communication = any act of social intercourse, 284
Communicative tendency = an innate tendency to social intercourse, 243
Complementaries (*or* **Complements**) = two hues which when combined produce gray, 76 f; black and white are considered complementaries, 77
Complex = (a) a composite experience; (b) in psychoanalysis: a subconscious (or repressed) emotional attitude, pathological in nature, which influences one's thoughts and actions
Composition = the mental process of uniting sensations into larger experiences, 129
Comprehension = (a) understanding spoken words, 291 n; (b) understanding
Conation (*or* **Expressive state**) = an experience made up largely of motor sensations, 224, 272
Concept = a special type of thought which tends to represent truly the characteristics and relations of things, 297
Concha = the outer shell of the ear, 85
Conduct = behavior which is directed toward other human beings; social behavior, 355
Conduction = the capacity of a neuron to propagate a nerve impulse from the receiving end through its entire length and collateral branches, 44
— **line** = the path traversed by any nerve impulse in the nervous system, 22
— **rate**, 307
Cones, retinal = small bodies in the retina of the eye, sensitive to both light and color, 60
Conflict, in learning = two or more responses involving partly similar neural connections, which thereby interfere with the fixation of a habit, 257
Conflicting associations, law, 188
Conscience = an attitude arising out of social relations and social experiences, 341 f
Conscious: when a living being is receiving sensations and having experiences, he ' is conscious,' 5, 123
— **operation**, *see* **Mental process**
— **phenomena**, *see* **Experience, conscious**
Consciousness (*or* **Awareness**) = a characteristic of mental life; the fact that a being has experiences, 122, 141; *cf.* **Conscious**
— **field of** = an individual's total experiences at a given moment, 138
— **lapsed** = the passage of consciousness into subconsciousness which takes place with the fixation of habits, 262
— **marginal, subliminal**, *see* **Experience**
— **stream of** = the general succession of experiences, 306, 327
Contiguity, law, 185, 186
Contrast = a complementary color effect seen on a white surface close beside a given color and induced by the latter, 78
Control = the effect of nervous and mental adjustment whereby a man or other creature is able to make responses suitable to the situation in which he is placed, 275, 315, 372 ff
— **center**, *see* **Center**
Convergence = fixating the foveas of the two eyes upon a single point, 156
Convolution (*or* **Gyre**) = an irregular rounded ridge in the surface of the cerebrum, Figs. 10–13
Coördination = the systematic distribution of nerve impulses through various motor paths, resulting in an orderly response, 53 f
Cord, *see* **Spinal cord**
Cornea = the transparent coat on the front surface of the eye, 59

Corpus callosum, *see* **Callosum**

Corpuscles = small bodies embedded in the skin, which serve as receptors for touch, warmth, and cold stimuli, 106

Corresponding points, retinal = any pair of points in the two retinas which yield a single sensation, 159

Cortex = the thin layer of gray matter which forms the outer surface of the cerebrum, 31

Corti, organ of = a system of cells within the cochlear duct in the cochlea of the ear, believed to be the receptor for hearing, 87, 89

Cranial = pertaining to the head; *cf.* **Nerve**

Curiosity = (a) an innate tendency to seek information, 242; (b) a general term, applied to many specific motor tendencies, such as reaching, grasping, biting, visual exploration, manipulation of objects, etc.

Cutaneous senses, 107; *cf.* **Touch, Warmth, Cold**

Deliberation = the delay, accompanied by thinking, which occurs in voluntary activity, 277

Delusion = a pathological condition in which imaginations are mistaken for reality, 200, 315

Demonstrations, in class exercises, 394

Depth, *see* **Perception**

Desire = an attitude embodying the permanent effects of feelings, 335 f

Development, mental = changes and improvements in mental operations and organization which occur during the individual's lifetime, 360 f, 370 f; *cf.* **Evolution**

Dextrality = an innate tendency to prefer one hand, etc., over the other in performing actions; e.g. right-handedness, 242

Difference, least observable, *see* **Least observable difference**

Difference tone = a third tone which arises when two tones are sounded together, due to their different vibration rates, 95

Diffused expression = imperfectly coördinated instinctive behavior stimulated by general systemic conditions, 239

Diffused response (*or* **movements**), *see* **Response, diffused**

Diffusion = an indefinite distribution or spreading of the nerve impulse, 256

Digestive sensations, 110

Direction = (a) the angle of a line or contour perceived by sight or touch, as indicated by muscle sensations or otherwise, 152; (b) the position of a visual or other distant-sense stimulus with reference to the observer, as indicated by muscle sensations in turning the eye or otherwise

Discrimination = the mental process of separating or distinguishing the parts of an experience, 129

— **perceptual**, *see* **Perception of difference**

— **subconscious**, 146

Discrimination time = the duration of that portion of a neural process which is concerned in discrimination, 310

Disorganization, mental = a reversal of the process of systematic mental organization, 369

Disposition = an attitude which embodies the permanent effects of emotional experiences, 337 f

— classification, 339

Dissociation (*or* **Dissociated experience**), *see* **Experience, subconscious**

Distance apart (*or* **Linear distance**) = apparent distance of objects from one another in the plane before us, 150; contrasted with **Depth**, or distance away from the observer

Distribution = the splitting up of a single nerve impulse, so that it passes into two or more different paths simultaneously, 47

Dizziness sensation, 119

Dorsal (*or* **Posterior**) = toward the back of the body, 27

Form-board = a board with depressions of various shapes into which solid blocks of the same shapes are to be inserted; used to test perception of shape or form, 174 f

Fovea centralis (*or* **Fovea**) = a depression in the retina near the rear midpoint of the eyeball, where sight is clearest, 62

Free nerve-endings = sensory neurons terminating in the skin and unattached to any receptor; they serve for the reception of pain stimuli, 113

Frequency, law, 186

Freudian psychology, *see* **Psychoanalysis**

Fringe of consciousness, *see* **Experience, marginal**

Function (*or* **Operation, Process**) = the 'working' of anything; the way in which something is accomplished, 39 ff; contrasted with **Structure**

— **biological** = a general type of bodily process which serves some biological purpose, 237 f

— **mental,** *see* **Mental process**

Fusion = a species of mental composition in which the elementary sensations merge together, 129

— **binocular (binaural)** = the single set of impressions which results from stimulation of the two eyes (ears), 159

— **tonal** = the modified effect of two or more tones when sounded together, 95

Ganglion = a small collection of nerve cell-bodies; *see* **Basal, Spinal, Sympathetic**

Generative (*or* **Sex**) **sensations** = organic sensations whose receptors are in the generative organs, 111

Gesture = communication by movements of the hands, etc., 288

Gland = a cell, tissue, or organ which separates materials from the blood or lymph and therewith produces certain chemical compounds in solution, called secretions, these secretions being either discharged directly on the surface of the body, or through ducts to the outside, or (in case of endocrine or ductless glands) into the blood or lymph, 51

Glandular response, *see* **Response**

Graphic language = communication by means of durable impressions in some material substance, 289 f; *cf.* **Language**

Gray = a sensation resulting from mixed light stimuli in which no single wave-length predominates, 69, 71; *cf.* **Shade**

Gray matter = grayish-looking masses of nerve tissue, consisting largely of cell-bodies, 31

Gustation, *see* **Taste**

Gustatory nerve = the sensory nerve for taste

Gyre (*or* **Gyrus**), *see* **Convolution**

Habit = an individually acquired and stereotyped series of responses or thoughts, 253

— **mental** = an acquired and definitely fixed train of thoughts or manner of thinking, 253

— **motor** = an acquired and definitely fixed complex motor response, 254

— relation to intelligence, 262 f

— training, 267

Habit conation = a sensory experience which accompanies the performance of an habitual act, 273

Habit formation, *see* **Learning**

Hallucination = confusion of images or thoughts with perceptions, 199

Hearing sense (*or* **Audition**), 85 ff

Heat sensation = a mingled impression of warmth and cold, 107

Hedonic = pertaining to feeling

Heft = to receive a muscle sensation from lifting, 162, 311

Hemispheres, cerebral, *see* **Cerebrum**

Heredity (*or* **Inheritance, Heritage**) = (a) any effect of the parental germ cell upon the nature of the new creature, 366 f; (b) the char-

change in the elementary sensations when they reach the higher centers, resulting in the formation of definite experiences, 127 f, 130; (b) often used to denote the succession of experiences
— **scale** = a graded series of mental tests, 347
— **state**, *see* **Experience**
— **succession**, *see* **Succession**
— **test** = a practical device for measuring an individual's mental development by his success in answering questions, solving problems, or performing prescribed acts, 15, 347 f
Mentality = *the degree of an individual's* mental development, 361
Metabolism = chemical changes in the body, 110 n, 112; *cf.* **Anabolism, Catabolism**
Mind = the total organization of experiences and personality in an individual, 17, 124 n, 365, 380
Mirror-writing (*or* **Mirror-script**), 163, 290
Mnemonic = pertaining to memory
Modification = the capacity of a nerve impulse to change its form, 48 f
Monocular, *see* **Uniocular**
Mood, *see* **Disposition**
Moral attitude, *see* **Conscience**
— **character**, *see* **Morality**
— **sentiment** = an experience which combines a feeling with the idea of right-and-wrong, 222
Morality = that phase of character which concerns man's relations to his *fellows* and is *developed* by social experiences, 354 f
Moron = a slightly retarded human being, 16 n
Motive = a conscious or subconscious condition which plays a part in determining one's behavior or conduct, 283, 337, 349, 355
Motor experience (*or* **Motor consciousness**) = organized information concerning one's own movements, 120, 224, 271; *cf.* **Conation**
— **organs**, *see* **Effectors**
— **senses**, *see* **Sense**
Movement = motion of an organism or its parts, produced by nerve impulses acting upon the muscles; *cf.* **Behavior, Response**
Müller-Lyer illusion, 170
Muscle = a contractile tissue operated by the motor nerves, 50 f
— **antagonistic**, *see* **Antagonists**
Muscle (*or* **Kinesthetic**) **sense** = a sense whose receptors lie in the muscles and other organs of movement, 115 f, 151
Myopia, *see* **Near-sight**

Nausea sensation, 111, 112, 119
Near-sight (*or* **Myopia**) = *a focusing* defect of the eye, due to too much curvature of the lens, whereby distant objects are blurred, 64 n
Nerve = a bundle of neurons lying side by side, and serving to conduct nerve impulses, 3, 26
— **cranial** = a nerve connecting with some receptor or effector in the head, 26, 29
— **motor** = a nerve leading from the cord or brain to some effector, 26
— **peripheral** = a nerve connecting the spinal cord or brain with a receptor or effector, 26
— **sensory** = a nerve leading from some receptor to the cord or brain, 26
— **spinal** = a nerve which passes from the body (below the head) into the spinal cord, 26, 29
Nerve fiber = the main stem of a neuron, 21
Nerve impulse, *see* **Impulse**
Nerve-study = in psychology: the study of the nervous system and its activities as bearing on mental life, 9
Nervous arc (*or* **circuit**) = the complete path traversed by any nerve impulse from receptor to effector, 23, 39
— — levels, 302 f
Nervous system = the sum-total of neurons (nerve cells) in the body, 3, 6, 19 ff, 39 ff